Production of Coho Reared in Sea-pens in Indian Arm, 1978 and 1979 Brood Years

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ABSTRACT

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During the fall of 1979 and 1980, approximately 120,000 and 100,000 coho fry respectively were transported from the Capilano hatchery to sea-pens in Indian Arm. Fry were reared for up to 11 months, then released the following year in three differentially tagged groups of different sizes on three separate dates (May, June and July). Approximately 91,000 and 85,000 coho smolts were released in 1980 and 1981 respectively. Sea-pen rearing survivals averaged 76% and 86% for the 1978 and 1979 broods respectively. The estimated smolt-to-adult survivals for the respective broods, based on tag recovery, were 10.2% and 9.0%. The July release groups had the lowest marine survival and smallest adult size but both June and July groups contributed more to the local Georgia Strait sport fishery compared to the May group. The project failed to provide a year-round local sport fishery in Indian Arm but showed that release size and timing may affect coho marine survival and adult size.

Key words: Indian Arm coho sea-pen rearing, release size and timing, salmonid enhancement

RÉSUMÉ

Fedorenko, A.Y. and E.A. Perry. 1984. Production of coho reared in sea-pens in Indian Arm, 1978 and 1979 brood years. Can. MS Rep. Fish. Aquat. Sci. 1768: 55 p.

Pendant les automnes de 1979 et de 1980, on a transporté respectivement 120 000 et 100 000 alevins de saumon coho de la piscifacture de Capilano à des enclos aménagés dans le bras Indian. La période d'élevage a duré jusqu'à onze mois; les alevins ont été mis en liberté l'année suivante, en trois groupes de tailles différentes étiquetés différemment, et à trois moments différents (mai, juin, juillet). On a par ailleurs relâché 91 000 jeunes saumons coho en 1980 et 85 000 l'année suivante. Les taux de survie des poissons élevés en enclos se situaient à 76% et 86% respectivement, pour les portées de 1978 et 1979. Si l'on se fie aux étiquettes récupérées, on estime que les taux de survie des saumoneaux de ces portées lors du passage à l'état adulte se situaient à 10,2% et 9,0%. Les poissons mis en liberté en juillet sont ceux qui ont le taux de survie en mer le plus bas; c'est également dans ce groupe qu'on retrouve les adultes les plus petits. Les poissons relâchés en juin et en juillet sont ceux qui ont le plus contribué à la pêche sportive dans le Détroit de Géorgie. Le projet n'a pas permis d'établir une pêche sportive locale qui s'étendrait sur toute l'année dans le bras Indian, mais a révélé que le moment choisi pour la mise en liberté des poissons et la taille des poissons à ce moment pouvaient influencer le taux de survie des saumons coho en mer et leur taille à l'état adulte.

Mots-clés: élevage en enclos de saumon coho dans le bras Indian, moment de mise en liberté et taille des individus, mise en valeur des salmonidés

INTRODUCTION

Indian Arm is located just northeast of Vancouver and forms the north extension of Burrard Inlet (Fig. 1). This extension is a typical British Columbia fjord, about 22 km long and 1 km wide, with mountains bordering its sides and shielding it from prevailing winds. Fishing opportunities in the Indian Arm and salmonid resource in the area are described by Fedorenko and Shepherd (1984).

Prior to 1979, transplant of coho juveniles into Indian Arm was attempted in August 1974 when 8,782 yearling coho were transported from Capilano hatchery and released in Indian Arm in the vicinity of the Buntzen Lake powerhouse (Fig. 1). Released coho weighed approximately 43 g each, and were adipose fin-clipped and coded wire nose-tagged using code 02-01-01. A total of 10 tagged coho adults (one 2-year old and nine 3-year olds) were recovered from this transplant, of which half came from the Bedwell Bay sport fishery (Appendix 1). This indicated that at least part of the transplanted coho population remained in or returned to the site of release in Indian Arm.

Between 1979 and 1981, DFO conducted coho sea-pen rearing in Indian Arm under contract to Indian Arm Salmon Ltd. (now Nevin Sadlier - Brown Goodbrand Ltd.). Coho fry from 1978 and 1979 brood stocks at Capilano were reared for up to 11 months in sea-pens located at the north end of Indian Arm, then released on three different dates (May, June and July) with each release differentially tagged. The rearing and release strategies were designed to encourage residualism in the inlet. Delayed salmon releases in which the artificial rearing period is extended beyond the time of normal release or migration, have been practiced in the inner Puget Sound since the early 1970's (Novotny 1975, 1980). Compared to earlier-timing releases, later releases of coho tended to remain within the Sound and contributed significantly more to the local recreational fishery (Novotny 1980).

Based on the successful results in Puget Sound, the extended sea-pen rearing of coho in Indian Arm was carried out in order to establish year-round local stock for fishing, and to determine if fish availability to the local sport fishery was a function of timing and size at release.

METHODS

COHO REARING 1979-1980

Between August 7 and 21, 1979, approximately 120,000 coho fry of the 1978 brood were vaccinated for vibriosis and transported from Capilano hatchery to the Wigwam Inn rearing site on Indian Arm (Figs. 1 and 2) by truck and boat. During transport fish were held in plastic bags filled with well-aerated water.

Fry were ponded into two floating net pens measuring 6 m x 6 m x 4.8 m deep with a 19 mm mesh size (Fig. 3). One pen was loaded with 50,000 fish and the other with 70,000 fish. A smaller net pen measuring 3 m x 3 m x 0.9 m deep with 6 mm mesh was placed inside the pen containing the 50,000 fry to hold an

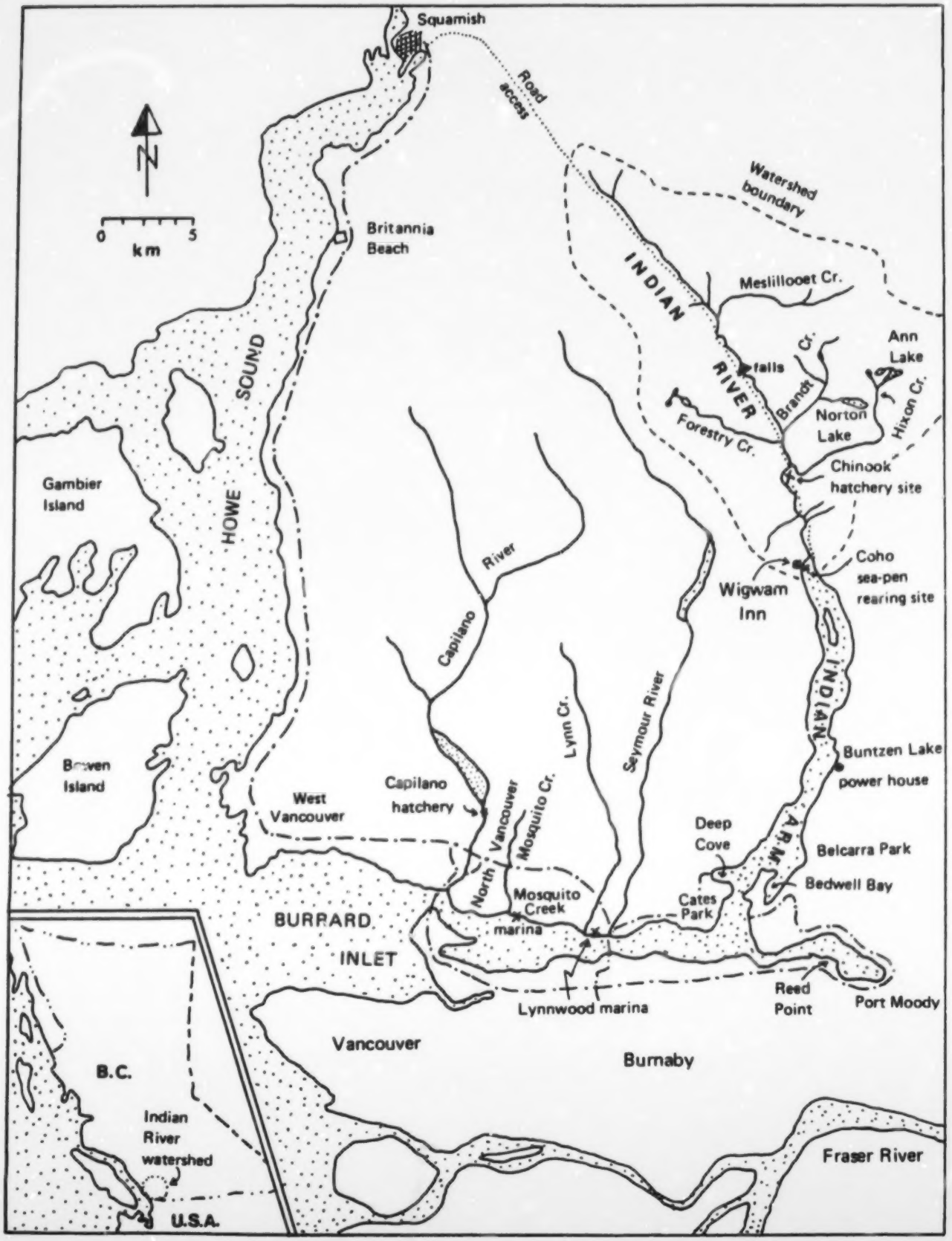

Fig. 1. Indian River watershed and the surrounding area.

Fig. 2. The Wigwam Inn coho rearing site at north end of Indian Arm, 1980.

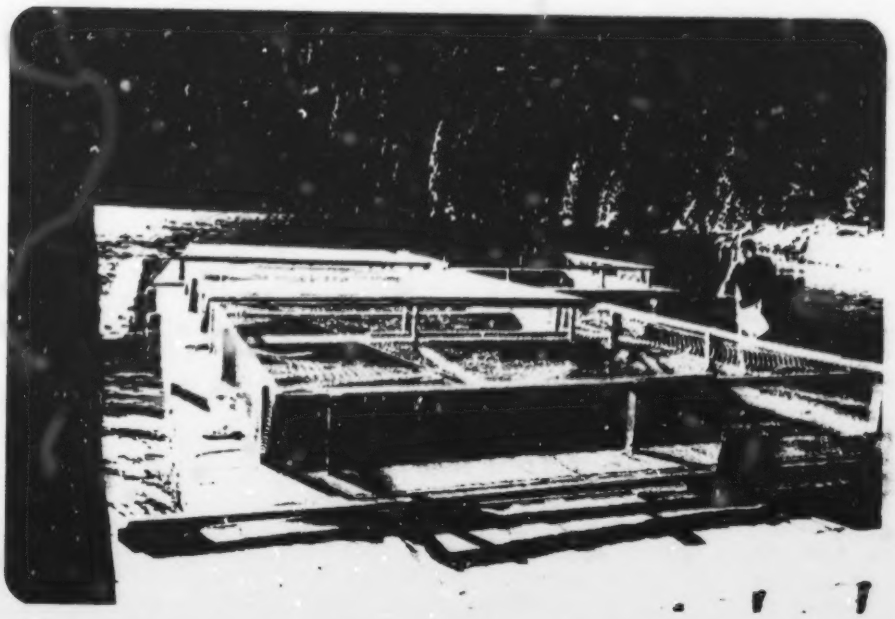

Fig. 3. Coho sea- pen rearing in Indian Arm, 1979 - 1981.

additional 2,136 coho fry. The latter fry were transported from the Capilano hatchery on June 27, 1979. These fish were not vaccinated for vibriosis in order to test the necessity of using the vaccine for this project. A third net was provided in April 1980 to allow for separate holding of the three groups of differentially tagged coho. All pens were covered with 6.4 cm mesh seine net to exclude predatory birds.

Coho were hand-fed according to the OMP (Oregon Moist Pellet) feeding schedule, initially every few hours from dawn to dusk, then less often as they grew. The OMP pellets ranged in size from 3/32" to 1/8". The Indian Arm Salmon Ltd. arranged for the Wigwam Inn staff to feed the fish whenever the regular feeders were absent.

Floating dead fish were counted and removed from the net pens daily. Nets were lifted and all dead fish removed only during periods of high mortality, in order to reduce stress on the fish. Due to fouling of nets with sea organisms, all nets were changed once during rearing.

Coho were reared until release in May, June or July of 1980.

COHO REARING 1980-1981

Between September 4 and November 13, 1980, approximately 100,000 coho fry of 1979 brood were vaccinated for vibriosis and transported from Capilano hatchery to the Wigwam Inn rearing site by truck and boat. During transport fish were held in a 2,300 l transport tank equipped with a compressed air cylinder to provide aeration. Fry were distributed among the three net pens as follows:

Transport date	Pen No. 1	Pen No. 2	Pen No. 3
Sept. 4-6	23,000		
Sept. 9		30,000	
Sept. 24		13,000	
Oct. 16			26,000
Nov. 13		8,000	
Total	23,000	51,000	26,000

The floating net pens initially were the same as those used in 1979 to 1980. The 26,000 fry ponded in pen No. 3 fed poorly and showed little growth. Therefore, they were transferred on December 11 into a smaller net pen measuring 3 m x 3 m x 2.4 m deep, in order to increase density and thereby enhance feeding response.

The feeding schedule was similar to that described for 1979-1980. OMP diet was fed from the time of ponding until March 3, 1981. Thereafter, fish in pens No. 1 and No. 2 were fed a dry Moore Clark diet and fish in pen No. 3 were fed a dry diet from Western Farmers Association according to the respective feeding schedules. The dry diets were easier to store and handle.

Mortalities were removed as in the previous year. Samples of diseased fish were sent for analysis to the Pacific Biological Station in Nanaimo on two occasions (March and June 1981). Prior to the March tagging program, the fish received a standard 10-day prophylactic treatment starting February 21 using Terramycin (TM-50). Due to fouling of nets with sea organisms, all nets were changed once during rearing.

Coho were reared until release in May, June or July of 1981.

COHO SAMPLING 1979-1980

Coho juveniles in each pen were generally sampled monthly in order to measure fish size and determine feeding schedule. During weighing, several hundred coho were dip-netted randomly out of each pen into a 23 l garbage pail partially filled with water. Fish were weighed in aggregate on a Kilo - Pound Beam medical scale to the nearest 0.25 kg. No samples were taken between November and February when the fish were on a maintenance diet of 1.8% of body weight per day. On release dates, a random sample of coho (n = 87 - 100) was weighed in aggregate and measured to the nearest 1 mm for individual nose-fork length.

COHO SAMPLING 1980-1981

Coho juveniles were sampled for weight at transfer from Capilano hatchery and then monthly in each pen in order to measure fish size and determine feeding schedule. The aggregate weighing method used in 1979 to 1980 was continued. In September and March, coho from each pen were also randomly sampled (n = 100) and measured to the nearest 1 mm for individual nose-fork length. On release dates, a random sample of coho (n = 100) was weighed in aggregate and measured for individual nose-fork length.

COHO TAGGING

Coho juveniles were marked with adipose fin-clips and coded wire nose-tags between April 2 and 21, 1980 and between March 9 and 19, 1981 at the Wigwam Inn rearing site. In each year, fish were divided into three groups and each lot was marked with a different tag code. After the tagging program was completed each year, the nets were lifted and the tagging mortalities counted and removed. Tag loss for the 1978 brood coho was determined by passing a sample of 250 to 600 fish from each net pen through a Quality Control Device. Tag loss for the 1979 brood coho was not determined.

PHYSICAL SAMPLING

Near-surface water temperatures at the rearing site were monitored daily during the 1979 to 1980 rearing period, and every few days during the 1980 to 1981 rearing period. Measurements were made to the nearest 0.5°C using a hand thermometer or a YSI Model 33 S-C-T Meter. Salinity was measured with a YSI Model 33 S-C-T Meter weekly at 0 m and 1 m depths from July to December 1979 when measurements were discontinued due to equipment failure, and at 1.8 m depth from September 1980 to July 1981.

COHO ADULTS

Commercial and sport catches of coho sampled by the Mark Recovery Program were used to evaluate the Indian Arm pen-rearing project. Project tags were recovered in B.C. and U.S. commercial and sport fisheries, and from the Capilano hatchery returns. Tags recovered in Indian Arm and the vicinity were turned over to head depots in Vancouver and Deep Cove (Fig. 1).

Most tags recovered in the B.C. commercial catch were obtained by DFO personnel using random sampling in the processing plants. A catch to sample ratio expansion factor was applied to the observed tags in order to estimate the total recoveries in the entire catch. Tags recovered in the U.S. waters were similarly expanded. A few tags in the B.C. commercial catch were recovered selectively by the cannery personnel. No expansion factor was available for these tags. Tags recovered in the B.C. sports fishery were adjusted by an expansion factor of three (Argue, Coursley and Harris 1977). No expansion factor was used for strays. As part of the Mark Recovery Program, all marked coho recovered in the canneries were measured for nose-fork length.

RESULTS AND DISCUSSION

COHO REARING 1979-1980

Of the 120,000 coho juveniles originally ponded, about 91,000 ± 2,401 ($p < 0.05$) remained in the net pens by April according to the tagging inventory (Table 1). The discrepancy of about 24% between the numbers of ponded and tagged fish included a known mortality of 1,600 coho and an undocumented loss of about 27,000 fish. The overall loss was attributed to mortality due to poor transport techniques, disease, tagging mortalities, cannibalism and to fish escaping from damaged net pens.

Poor transport technique during fish transfer from the Capilano hatchery to the rearing site in August resulted in the observed loss of 1,253 fry out of the approximately 120,000 fish transported in plastic bags. Most of this mortality occurred in the first shipment before the technique was improved by reducing fish handling.

An outbreak of vibriosis occurred in September in the small net pen containing the first lot of unvaccinated 2,136 fry. By September, 233 dead fish were removed from this pen and the entire unvaccinated lot was destroyed in order to prevent the spread of disease. The two large net pens containing the vaccinated 120,000 fish were lifted on September 28 and 50 dead fish were found. Tagging mortality totalled 119 fish. The additional approximately 27,000 coho lost unaccountedly either perished from cannibalism (508 large coho weighing 250 g to 450 g were released during tagging in April) or escaped through a small tear discovered in pen No. 2 during tagging. Based on the tagging inventory in the undamaged pen No. 1, mortality through cannibalism was probably around 15% (18,000 fish) of the total ponded coho, and 7.5% (9,000 fish) may have escaped.

Table 1. Tagging summary for 1978 brood coho reared in Indian Arm net pens, 1979-1980.

Pen No.	Tag code	Tagging period	No. tagged	Tagging mortality	Tag loss (n) [a] %	No. rearing after tagging: Marked[b]	Ad-clip only	Unmarked	Total
1	02-17-12	Apr. 2-9	26,176	18	(263) 2.7%	25,452	706	0	26,158
2	02-17-13	Apr. 10-16	24,940	18	(242) 7.0%	23,177	1,745	0	24,922
3	02-17-14	Apr. 16-21	26,084	83	(372) 4.0%	24,961	1,040	14,049[c] ±2,401[d]	40,050± 2,401[d]
Total	-	-	77,200	119	(877) -	73,590	3,491	14,049 ± 2,401[d]	91,130[d,e] ± 2,401
Mean	-	-	-	-	- 4.4%				

[a] "n" gives sample size.

[b] Corrected for tagging mortality and tag loss.

[c] Estimated 14,049 fish remained unmarked based on tagged:untagged ratio of 372:201 in a mixed sample from that net pen.

[d] 95% confidence limit.

[e] Additional 508 oversize coho released unmarked to reduce cannibalism.

COHO REARING 1980-1981

Of the 100,000 coho juveniles originally ponded about 86,000 remained in the net pens by March according to the tagging inventory (Table 2). The discrepancy of about 14% between the numbers of ponded and tagged fish was attributed to mortality due to disease, smolting abnormalities, cannibalism and to fish escaping from damaged net pens. There were no observed transport mortalities.

In March 1981, a few fish showed disease symptoms diagnosed as bacterial kidney disease by Disease Diagnostics Staff at the Pacific Biological Station. However, probably less than 0.5% of the rearing coho were affected. In mid-June, rearing mortalities increased. A sample of diseased fish sent on June 17 to the Pacific Biological Station showed bacterial kidney disease and a problem with smolting made evident by descaling. The fish with smolting abnormalities had ceased feeding and were starving to death. Between June 9 and July 21, 709 dead coho were removed, mostly from pen No. 3.

Tagging mortalities were negligible and cannibalism was probably considerably lower than in the previous year; only 20 oversize coho were removed from the net pens in March 1981 compared to the 508 coho removed in April 1980.

During both years of coho pen-rearing in the Indian Arm, difficulties were encountered in keeping an accurate count of fish mortalities. Such difficulties are common during sea-pen rearing (Novotny 1980). During the Indian Arm coho rearing program, the initial numbers of fry ponded were estimates based on the total and mean fish weights. However, individual fish sizes were highly variable. For example, fish sampled soon after ponding in September 1980 ranged from 4 cm to 10 cm in length. In addition, dead fish did not always float to the surface but sank to the bottom of the pens. In order to record the latter mortalities, the nets would have to be lifted at least twice weekly because dead fish decompose very rapidly in net pens. However, this method would have been very stressful to the remaining fish and so was avoided.

Finally, mortalities due to cannibalism were undetermined. This type of mortality was probably significant since large coho weighing up to 450 g were recorded in the net pens. These large individuals no doubt preyed on the much smaller general rearing population. Predation by coho on highly concentrated fry has been reported by Parker (1971) and Beall (MS 1972).

The outbreaks of bacterial kidney disease in March and June 1981 may have been related to the replacement of OMP diet by dry diets in early March. Wood (1974) reported that an increased incidence of bacterial kidney disease was found among salmon fed a dry diet compared to an OMP diet.

COHO SAMPLING 1979-1980

Mean weights of coho juveniles rearing in the Indian Arm between June 1979 and July 1980 are shown in Figure 4 and Appendix 2. Fish increased in weight from 2-3 g at ponding in June and August, to 38 g by late July of the following year. Mean lengths of fish released on June 27 and July 28, 1980 were 14.6 cm

Table 2. Tagging summary for 1979 brood coho reared in Indian Arm net pens, 1980-1981.

Pen No.	Tag code	Tagging period	No. tagged	Tagging mortality	Tag loss[a] %	No. rearing after tagging			
						Marked[b]	Ad-clip only	Unmarked	Total
1	02-19-12	Mar. 9-19	26,762[c]	0	4.4%	25,584	1,178	0	26,762
2	02-19-13	Mar. 11-16	26,881	0	4.4%	25,698	1,183	~ 10,000[d]	36,881
3	02-19-14	Mar. 17-19	22,526	0	4.4%	21,535	991	0	22,526
Total	-	-	76,169	0	-	72,817	3,352	~ 10,000	86,169[e]

[a] Mean tag loss for 1978 brood coho (Table 1).

[b] Corrected for tag loss.

[c] Supplemented by several thousand fry from pen No. 2.

[d] Approximately 10,000 fry remained unmarked based on a visual estimate.

[e] Additional 20 oversize coho released unmarked to reduce cannibalism.

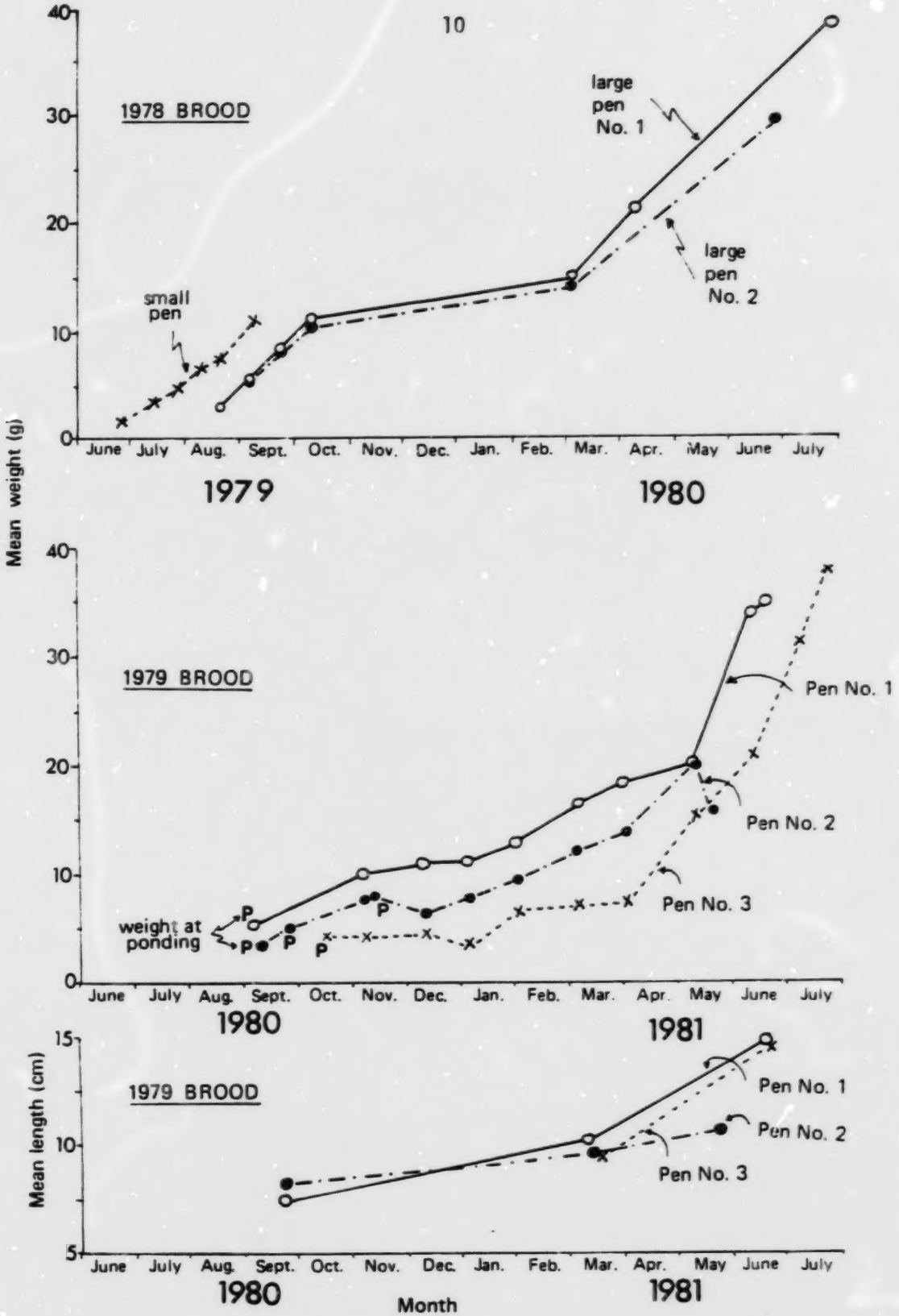

Fig. 4. Mean weights (1978 and 1979 broods) and mean lengths (1979 brood) of coho juveniles rearing in Indian Arm , 1979 - 1981.

and 15.5 cm respectively. No length data at release were available for the May group since the majority of these fry escaped prior to release date (see release section below).

Growth was negligible during the winter months when the fish fed poorly. From March to July of the following year, the fish increased steadily in weight. Size increases were generally similar for the three net pens, but fish were slightly larger in the small net pen at any time, due largely to their earlier ponding (Fig. 4).

COHO SAMPLING 1980-1981

Mean lengths and weights of coho juveniles rearing in the Indian Arm between September 1980 and May to July 1981 are shown in Figure 4 and Appendices 3 & 4. Fish increased in size from around 5 g and 7 cm in September to around 38 g and 14 cm by late July of the following year.

Growth was slow during the fall and winter months, but increased rapidly from April to July of the following year. Size increases were similar for the three net pens, but fish were generally largest in pen No. 1 and smallest in pen No. 3 at any time. This difference was due largely to the fact that fish in pen No. 3 were ponded last, and at a smaller size compared to the other fish. The direct relationship observed between the accumulated thermal units and the mean fish weights for each of the three net pens (Fig. 5) indicated that the rearing temperatures had a strong effect on growth rate in all pens.

Size increases for the two coho broods could not be compared due to insufficient data. Also an additional variable was introduced by the use of different diets: only OMP for the 1978 brood, and OMP followed by the Moore Clark dry diet or the Western Farmers Association dry diet for the 1979 brood. However, despite the diet differences, final fish size appeared to be similar for the two brood years (effects of different diets on growth rates could not be determined for the 1979 brood due to limited data). Size comparison between the two broods was further complicated since growth of the individual rearing coho was not uniform. For example, in April 1980 when the mean fish weight was 20 g, over 500 coho weighing between 250 g and 450 g were removed from net pens. Fish growth may have been somewhat more uniform during the 1980 to 1981 rearing period when only 20 oversize coho were removed during March 1981.

COHO TAGGING 1980

A tagging summary for the 1978 brood coho is given in Table 1. A total of 73,590 coho were separated into three near-equal groups and tagged during April 1980 using three different tag codes; 02-17-02, 02-17-13 and 02-17-14. The above total has been corrected for a tagging mortality of 119 fish and a tag loss that ranged from 2.7% to 7.0% per pen.

As a result of tag loss, an estimated 3,491 coho were adipose-clipped only. An additional estimated 14,049 ± 2,401 ($p < 0.05$) coho in pen No. 3 remained unmarked (Table 1). This was determined using the tagged:untagged fish ratio of 372:201 from a mixed sample of 573 coho from pen No. 3.

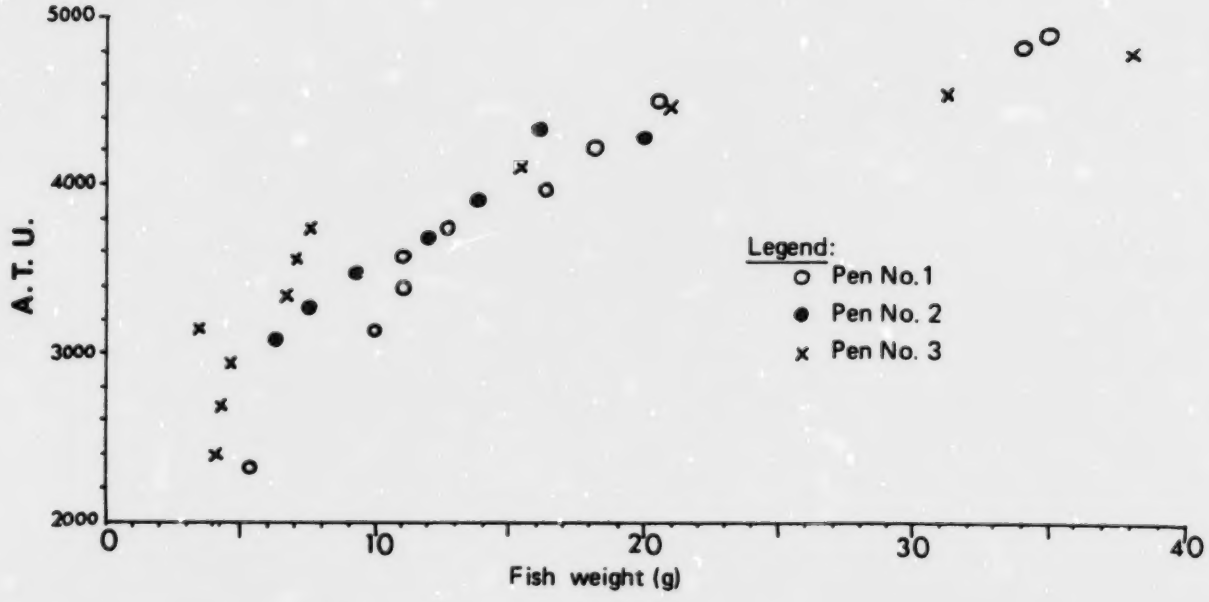

Fig. 5. Relationship between accumulated thermal units (A.T.U.) and mean fish weight for coho juveniles rearing in Indian Arm, 1980-1981.

Size of coho during tagging was about 18 g to 24 g based on the seasonal size data (Fig. 4). By April 21 when the tagging was completed, all coho in pens were smolted and beginning to lose scales.

COHO TAGGING 1981

A tagging summary for the 1979 brood coho is given in Table 2. A total of 72,817 coho were separated into three near-equal groups and tagged during March 1981 using three different tag codes: 02-19-12, 02-19-13 and 02-19-14. The above total has been corrected for a tag loss of 4.4% based on the mean tag loss for the 1978 brood coho (Table 1). Tagging mortality was negligible.

As a result of tag loss, an estimated 3,352 coho were adipose-clipped only. An additional estimated 10,000 coho in pen No. 2 remained unmarked, based on a visual estimate (Table 2).

Size of coho during tagging was about 7 g to 17 g based on the seasonal size data (Fig. 4). At tagging, almost all the fish in pen No. 1 and the larger fish in pens No. 2 and No. 3 were smolted.

COHO RELEASE 1980

Coho releases for the 1978 brood year are summarized in Table 3. An estimated 91,110 coho consisting of 73,570 differentially tagged fish, 3,491 adipose-clipped only fish and 14,049 unmarked fish were released in three groups in 1980: approximately 25,000 by May 23, 40,000 on June 27 and 26,000 on July 28. The majority of fish in the May 23 release group escaped through a hole in the net pen sometime between tagging and release dates. An additional 508 oversize coho were released unmarked during tagging in April to reduce cannibalism, bringing the release total to 91,618 fish.

Mean fish sizes at release were about 25 g for the May 23 group, 29.6 g and 14.6 cm for the June 27 group, and 38.3 g and 15.9 cm for the July 28 group. The mean weight for the May release group was estimated from seasonal size data (Fig. 4) since the majority of fish from this lot escaped earlier. Coho released in June and July appeared to be in poor condition, with scaling quite evident.

Overall rearing survival from transfer out of Capilano hatchery to release, was 76.3%.

COHO RELEASE 1981

Coho releases for the 1979 brood year are summarized in Table 4. An estimated 85,460 coho consisting of 72,108 differentially tagged fish, 3,352 adipose-clipped only fish and about 10,000 untagged fish were released in three groups in 1981: approximately 37,000 by May 21, 27,000 on June 19 and 22,000 on July 21. About half of the fish in the May 21 release group escaped through a hole in the pen prior to hole discovery on May 11. An additional 20 oversize coho were released unmarked during tagging in March to reduce cannibalism, bringing the release total to 85,460 fish.

Table 3. Release summary for 1978 brood coho reared in Indian Arm net pens, 1979-1980.

Date of release	Tag code	No. released				Mean size at release		
		Marked	Ad-clip only	Unmarked	Total	W (g)	L (cm)	(n)[a]
May 23/80	02-17-13	23,177	1,745	0	24,922	25[b]	-	
June 27/80	02-17-14	24,961	1,040	14,049	40,050	29.6	14.6	(87)
July 28/80	02-17-12	25,432[c]	706	0	26,138	38.3	15.9	(100)
Total	-	73,570	3,491	14,049	91,110[d]	-	-	-

[a] Length sample size.
[b] Estimated from seasonal size data.
[c] Corrected for rearing mortality of 20 tagged fish observed at release time.
[d] An additional 508 oversize coho were released untagged during tagging in April to reduce cannibalism.

Table 4. Release summary for 1979 brood coho reared in Indian Arm net pens, 1980-1981.

Date of release	Tag code	No. released				Mean size at release		
		Marked	Ad-clip only	Unmarked	Total	W (g)	L (cm)	(n)[a]
May 21/81[b]	02-19-13	25,698	1,183	~ 10,000	36,881	16.0	11.2	(100)
June 19/81	02-19-12	25,384	1,178	0	26,562	35.0	14.5	(100)
July 21/81	02-19-14	21,026	991	0	22,017	38.0	13.9	(100)
Total	-	72,108	3,352	~ 10,000	85,460[d]	-	-	-

[a] Length sample size.
[b] About half the fish in that group escaped prior to May 11 (see text).
[c] Corrected for June rearing mortality: 200 coho in pen No. 1 and 509 coho in pen No. 3.
[d] An additional 20 oversize coho were released unmarked during tagging in March to reduce cannibalism.

Mean fish sizes at release were 16.0 g and 11.2 cm for the May 21 group; 35.0 g and 14.6 cm for the June 19 group, and 38.0 g and 13.9 cm for the July 21 group. Most of the fish were smolted at release time.

Overall rearing survival from transfer out of Capilano hatchery to release, was 85.5%.

PHYSICAL SAMPLING

Near-surface water temperatures and salinities measured at the Indian Arm rearing site during the 1979 to 1980 and 1980 to 1981 rearing periods are shown in Figure 6 and Appendices 5 to 8. Seasonal water temperatures were similar for the the two rearing periods. Temperatures declined from around 16°C in early September to about 6 to 7°C by December, then increased gradually to about 14°C by July. The greater depth of (0.6 m) monitored during 1980 to 1981, compared to the near-surface station monitored during 1979 to 1980, is partly responsible for the slightly lower temperatures observed during the 1980 to 1981 period. The more extensive temperature records available for the 1979 to 1980 period showed maximum seasonal temperatures of about 20°C during late July and early August.

In 1979, surface salinities measured between July and December fluctuated greatly and ranged between 1 and 15.5 parts per thousand probably due to tidal influence, flow from Indian River and precipitation. Salinities at 1 m depth ranged between 6 and 19 parts per thousand and were consistently higher with less fluctuation than the surface salinities.

During 1980 to 1981, salinities measured at 1.8 m depth fluctuated greatly during fall and winter and ranged between 0 and 13.5 parts per thousand. This fluctuation may have been related to storms and freshets. More stable salinities averaging 9 parts per thousand were recorded in the spring of 1981.

Unfortunately, oxygen levels were not monitored and were assumed to be at saturation levels near the surface. Low dissolved oxygen concentrations have been occasionally experienced in large net pens in Puget Sound during slack tides (Novotny 1975). It is therefore possible that dissolved oxygen content in the net pens in Indian Arm was at times below saturation although no evidence of oxygen-related stress was seen.

COHO ADULT RETURNS

The adult catch returns from each release group (May, June and July) were estimated using the total marks recovered in the B.C. and U.S. catches, adjusted by fish sampling factor (see methods). Escapement to Indian Arm was not monitored and no recovery programs were conducted in Indian River or any other nearby stream such as the Capilano and Seymour rivers. However, the few surveys of Indian River conducted by Fishery Officers indicated a higher than normal abundance of coho in the river during the fall of 1980, 1981 and 1982 (Max Tscharre, DFO, pers. comm.). Some of these coho were missing an adipose fin and probably originated from the Indian Arm sea-pen releases . A one-day exploratory attempt was made in Indian Arm by DFO in June 1982 to determine if there was a significant resident coho population in the inlet prior to normal spawning migration, but the attempt was absorted due to heavy contamination of

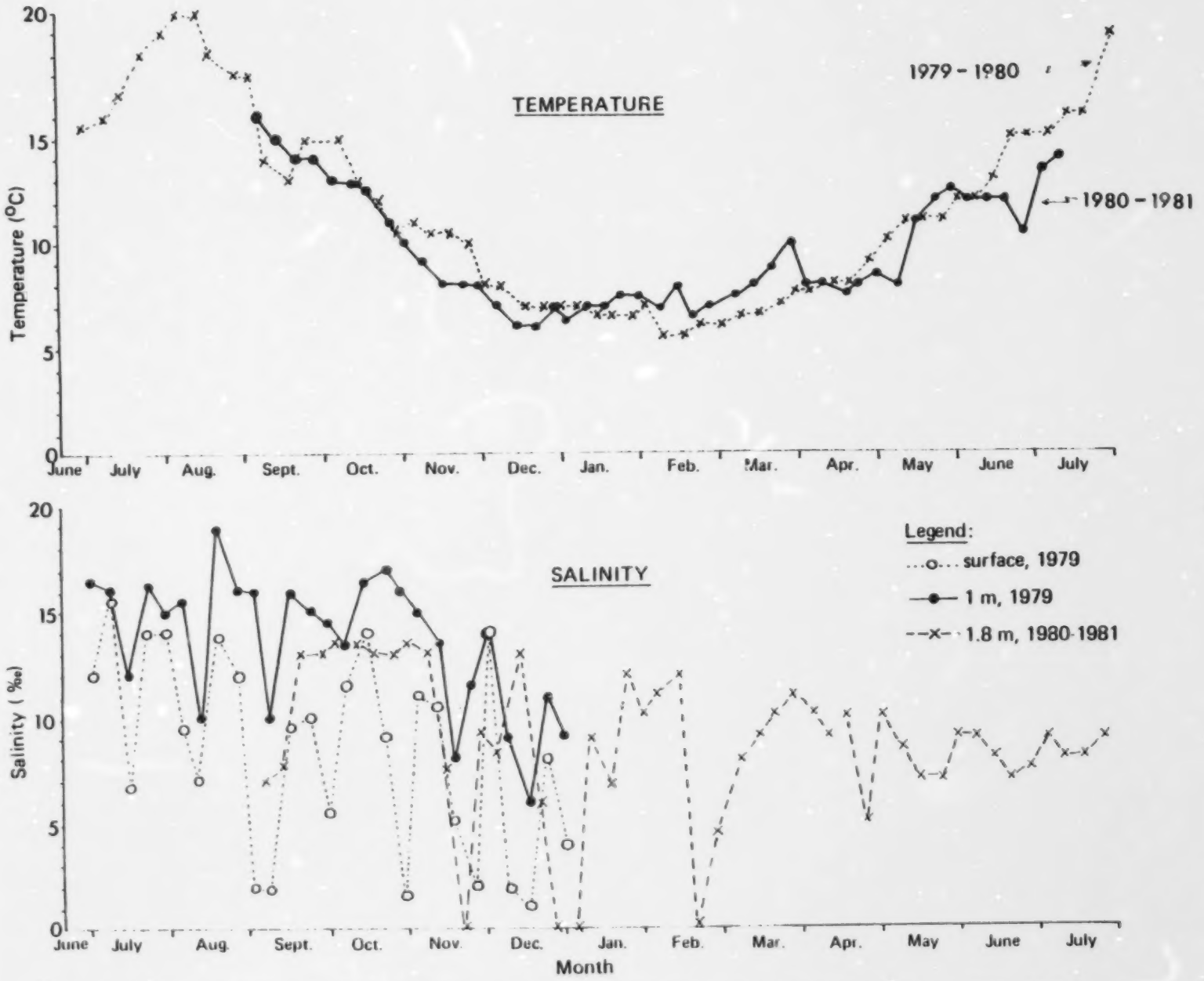

Fig. 6. Mean weekly surface water temperatures and salinities at the coho pen rearing site, Indian Arm, 1979 - 1981.

seine nets with jelly fish (M. Farwell, DFO, pers. comm.). Escapement of coho to Indian Arm was therefore calculated indirectly using the C/E ratio obtained from selected June releases of Capilano hatchery coho from the 1978 and 1979 broods (3.3/1 and 1/1 respectively; Appendix 11). The appropriate ratio was applied to estimated catch of Indian Arm releases in order to give an approximate value for total return and survival of each release group.

In order to facilitate calculations of marine survival and catch distribution, the Indian Arm tagged returns were not expanded to cover the untagged population which represented only about 20% of the original Indian Arm releases. However, an expansion factor for each brood year (total juveniles released/tagged juvenile released) was used to calculate, from the tagged catch returns, the contribution of coho reared in Indian Arm to the Canadian sport and commercial fisheries. The total Indian Arm coho tag recoveries in the Canadian catch were 4,523 and 2,529 for the 1978 and 1979 broods respectively (Appendices 9 and 10). Expansion factors correcting for the untagged juvenile releases were 1.25 for the 1978 brood (Table 3) and 1.19 for the 1979 brood (Table 4). Applying the appropriate expansion factor to the tagged catch originating from each brood year gave an estimated contribution to the Canadian sport and commercial fisheries of 5,654 coho from the 1978 brood and 3,010 coho from the 1979 brood.

The percent of marks recovered from each brood year and release group is calculated in Appendices 9 and 10, and is summarized below (Table 5):

Release group	Total % recovery	
	1978 brood	1979 brood
May	12.0	11.5
June	13.5	8.1
July	5.5	6.9
Total	10.2	9.0

The estimated brood smolt-to-adult survival of Indian Arm coho, based on tag returns, was 10.2% for the 1978 brood and 9.0% for the 1979 brood. The May and June releases from both brood years showed a higher recovery rate (8.1% - 13.5%) compared to the July release groups (5.5% - 6.9%).

The above survival rates were compared to those for the Capilano hatchery and Sechelt coho for the corresponding brood years and release groups. The coho sea-pen rearing project at Sechelt is located in the extreme southern end of the Sechelt Inlet (Fig. 8). The project is directed by the Community Economic Development Project section of SEP and operated by the Sechelt Indian Band. Since 1979, coho fry from the Capilano hatchery have been transported to Sechelt for rearing and release the following spring. Coho released into Indian Arm and Sechelt Inlet, and from the Capilano hatchery were all of the same donor stock.

Marine survival rates for the Indian Arm June releases of 13.5% and 8.1% were comparable to the Capilano coho survival rates of 15.4% and 10.3% for the corresponding brood years and release times (Table 5). Marine survival rates for the Indian Arm July releases of 5.5% and 6.9% were similar to the survival rate for 1978 brood June/July release of Sechelt coho of 6.4% (Table 5). However, the above survival comparisons are complicated by the fact that for a given release group, smolt sizes at release were considerably smaller for the Capilano and Sechelt coho compared to the Indian Arm coho (Table 5).

Table 5. The estimated total tagged returns (catch plus escapement) and marine survival of coho from Indian Arm, Capilano hatchery and Sechelt Inlet, 1978 and 1979 broods.[a]

Release group[b]	No. tags released	Catch	Escapement	Total return	% Marine survival
Indian Arm 1978 brood					
May release (~ 25 g)	23,177	2,128	645	2,773	12.0
June release (29.6 g)	24,961	2,586	784	3,370	13.5
July release (38.3 g)	25,432	1,067	323	1,390	5.5
Total	73,570	5,781	1,752	7,533	10.2
Indian Arm 1979 brood					
May release (16.0 g)	25,698	1,479	1,479	2,958	11.5[c]
June release (35.0 g)	25,384	1,033	1,033	2,066	8.1[c]
July release (38.0 g)	21,026	722	722	1,444	6.9[c]
Total	72,108	3,234	3,234	6,468	9.0[c]
Capilano hatchery 1978 brood					
June release (13.3 g)	53,942	6,395	1,935	8,330	15.4[d]
Capilano hatchery 1979 brood					
June release (15.9 g)	52,709	2,727	2,727	5,454	10.3[c,d]
Sechelt Inlet 1978 brood					
June/July release (21-31 g)	19,966	988	299	1,287	6.4

[a] For details see Appendices 9-12.
[b] Mean fish weight is given in parenthesis.
[c] May be slightly underestimated since finalized returns of 3- and 4-year old coho were not available.
[d] May be slightly underestimated since hatchery escapement is conservative.

The marine survival rates for Indian Arm coho suggest that the 16 g to 25 g May releases and 30 g to 35 g June releases resulted in a higher oceanic survival and therefore higher overall fishery benefits compared to the delayed 38 g July release. By comparison, Novotny (1980) described a study where the total mark recovery was greatest for the largest sized and most delayed release group:

Release group	Size at release	Total % recovery
May 1	22 g	4.2
June 1	23 g	8.1
June 27	38 g	16.2

Buckley and Haw (1978) also found that delayed releases of larger coho during June to August resulted in greater contribution to both recreational and commercial fisheries (8.2 - 11.8%) than the earlier May release (3.5%). The above authors concluded that a delay in release time and the resultant increase in size, combine to give significantly improved benefits to Washington fisheries. Similarly, Salmon Culture Div. (1977) reported that both time and size of smolts at release affected marine survival; survival rates tended to increase with later release time and greater size at release. However, studies by Bilton (1978) indicated that larger size at release did not necessarily result in increased adult production.

The smolt-to-adult survival of 1978 brood Indian Arm coho released in May and June (12.0% - 13.5%) was slightly lower than the 15% mean smolt-to-adult survival established for reared coho in the Salmonid Enhancement Program Design Criteria (updated in 1982); likewise, smolt-to-adult survival of the Capilano hatchery coho has averaged 15%. The smolt-to-adult survival of 1979 brood Indian Arm coho released in May (11.5%) and June (8.1%) was considerably lower partly due to incomplete recovery data (Table 5).

COHO ADULT TAG DISTRIBUTION

Tag distribution for each brood year and release group is shown in Figure 7 and Table 6. Detailed data for Indian Arm coho are presented in Appendices 9 and 10. Detailed data for Capilano hatchery and Sechelt coho are shown in Appendices 11 and 12 respectively. B.C. catch regions and their corresponding Statistical Areas are shown in Figure 8 and Appendix 13.

About 50% of all tags recovered from each brood year came from the "inside waters" (Georgia Strait and Fraser River), and the fewest tags (less than 4%) came from Northern and Central B.C. Tag recoveries from the West Coast of Vancouver Island, Juan de Fuca Strait and Johnstone Strait were generally comparable to one another and ranged from 5% to 11% of the total recovery. Tag recoveries in Washington and Oregon were relatively high at 22% for both brood years. Similarly, tag distribution of Capilano hatchery coho released in June (1978 and 1979 broods) and of Sechelt coho released in June/July (1978 brood) also showed that recoveries were highest in the "inside B.C. waters" (58% - 69%) followed by Washington and Oregon (12% to 17%; Table 6).

Among the individual Indian Arm release groups, the June and July releases

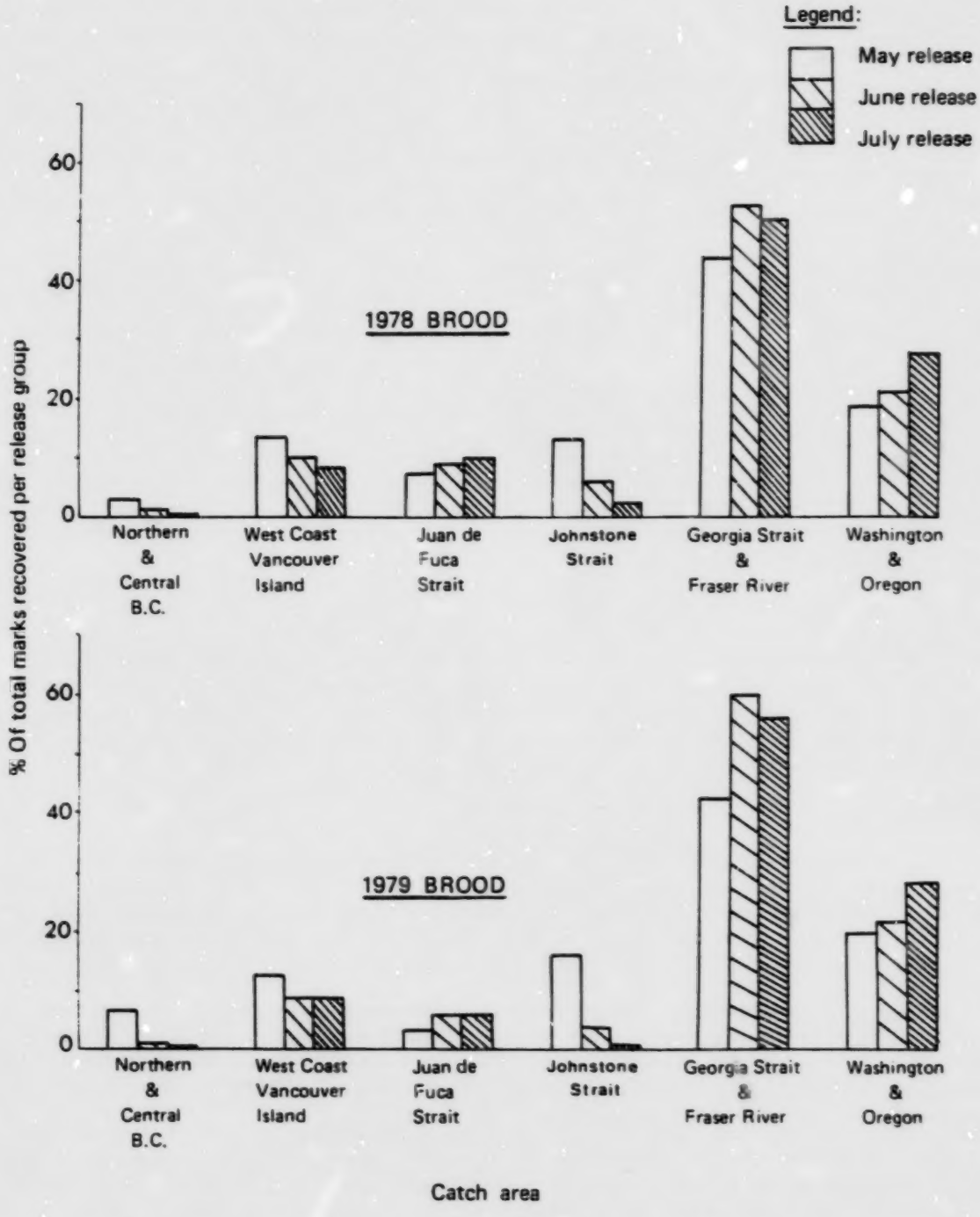

Fig. 7. Distribution of marks recovered in B.C. and U.S. waters by release group for 1978 and 1979 brood coho pen-reared in Indian Arm.

Table 6. Percent distribution of catch mark recoveries by brood and tag code of coho from Indian Arm, Capilano hatchery and Sechelt Inlet, 1978 - 1979 broods.

Release date	% TAG DISTRIBUTION								Total	
	Georgia Strait	Fraser River[a]	Juan de Fuca Strait	Johnstone Strait	West Coast Van. Isl.	North + Central B.C.	Other B.C.	Wash + Ory.	No.	(%)
INDIAN ARM 1978 BROOD										
May 23/80	42.0	2.2	7.2	13.0	13.5	3.1	0	18.9[b]	2,139	(100)
June 27/80	51.3	1.4	8.9	6.0	10.0	1.2	0	21.2	2,610	(100)
July 28/80	49.7	0.7	9.9	2.6	8.3	0.7	0	28.0	1,072	(100)
Total	47.6	1.6	8.5	8.0	11.0	1.8	0	21.6	5,821	(100)
INDIAN ARM 1979 BROOD										
May 21/81	41.9	1.0	3.2	16.0	12.3	6.8	0	18.9	1,485	(100)
June 19/81	58.2	1.5	5.8	3.6	8.9	0.9	0	21.2	1,042	(100)
July 21/81	54.7	1.4	5.9	0.8	8.8	0.4	0	28.0	726	(100)
Total	50.0	1.3	4.6	8.6	10.4	3.5	0	21.7	3,253	(100)
CAPILANO HATCHERY 1978 BROOD										
June 6/80	56.6	1.2	9.5	-[c]	-[c]	-[c]	15.9	16.9	6,395	(100)
CAPILANO HATCHERY 1979 BROOD										
June 6/81	57.5	1.3	5.7	-[c]	-[c]	-[c]	18.3	17.0	2,710	(100)
SECHELT INLET 1978 BROOD										
June/July/ 80	69.0	0	3.8	1.8	10.9	1.9	0.1	12.3	988	(100)

[a] Includes strays to Capilano hatchery.
[b] Includes four tags recovered in Alaska.
[c] Included in "Other B.C." group.

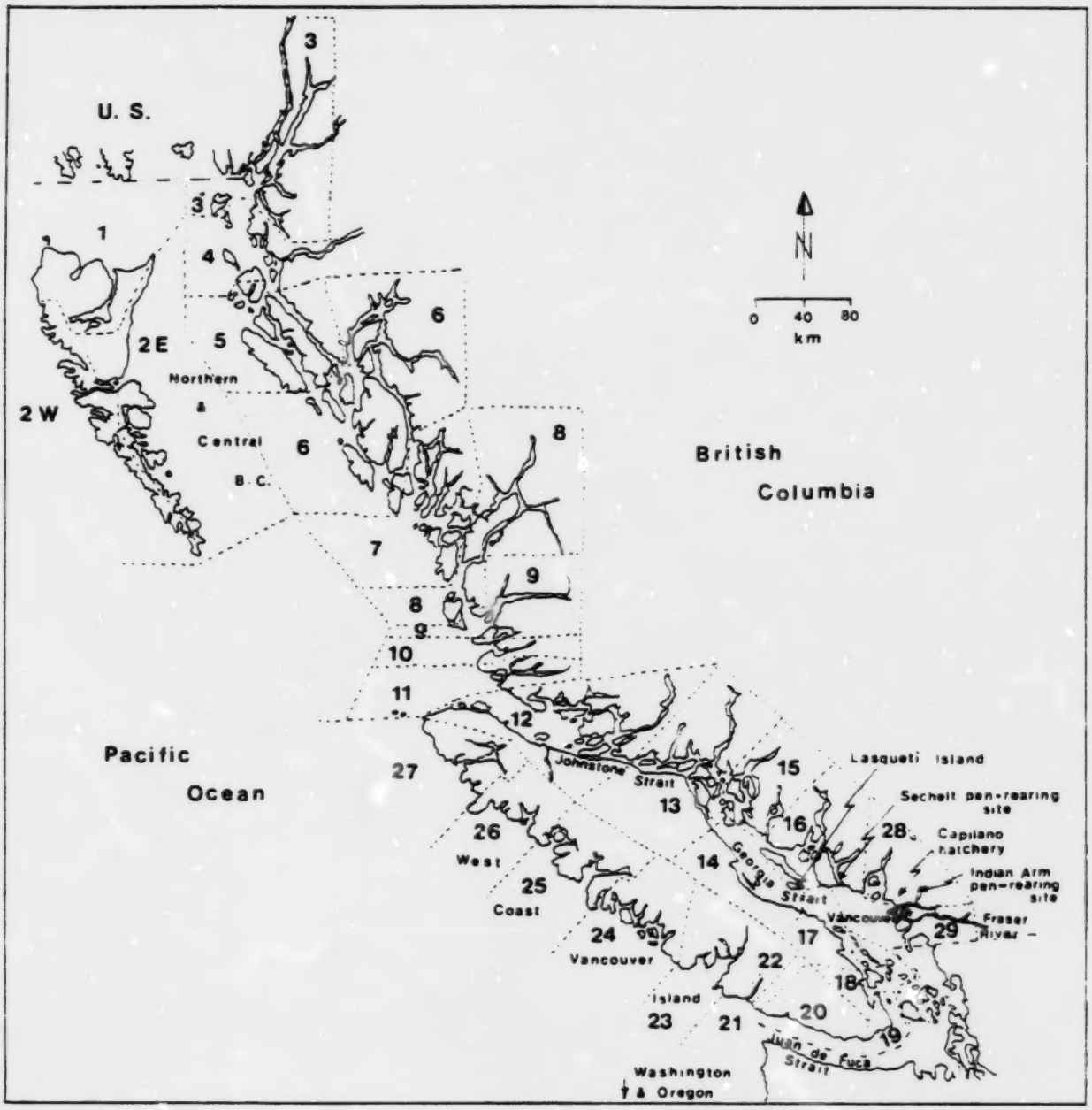

Fig. 8. Statistical fishing zones in British Columbia.

from both brood years contributed more to the "inside" fishery (50% to 60%) than did the May group (44%; Table 6). Compared to the May group, the later releases also contributed more to the Juan de Fuca Strait and Washington and Oregon fisheries. On the other hand, the May release group contributed considerably more to the Northern and Central B.C. and the Johnstone Strait fisheries than did the later releases, and slightly more to the West Coast Vancouver Island fishery (Table 6).

The above differences in catch distribution among the different release groups indicate that delayed June and July coho releases may result in altered adult migration routes and geographical distribution such that a larger proportion remain in more local waters. It is interesting however that the Indian Arm releases contributed proportionally fewer fish to the inside fisheries than did Capilano releases. The sea-pen operation was designed specifically in an attempt to encourage local fisheries but this appears to have failed.

Different sizes at release may be also related to changes in the marine distribution of adults. In the Indian Arm study, the larger juveniles released in June and July contributed more to the "inside" fishery compared to the smaller juveniles released in May. Similarly, studies in Washington and Oregon showed that March releases of 50 g coho juveniles contributed significantly more to the coastal fishery compared to March releases of 20 g juveniles (Johnson 1970; Wash. Dept. Fish. 1971). Studies by Buckley and Haw (1978) also showed that a delay in release time, and the resultant increase in size, combine to give significantly improved benefits to Washington fisheries. Novotny (1980) observed similar differences in adult migration patterns, between normal and delayed releases of coho. Although a normal release on May 1, 1973 from Skykomish River hatchery produced a higher total percent recovery (8.4%) compared to delayed release on July 29 (only 4.6%), a much higher percent of delayed July releases was recovered in the Puget Sound sport fishery (13.7% vs 1.0%) indicating a more local fish distribution. Contrary to this, proportionately more catch was observed in Washington and Oregon fisheries the later the release date from Indian Arm.

CONTRIBUTION OF COHO ADULTS TO THE GEORGIA STRAIT SPORT FISHERY

Tag recovery from the Georgia Strait sport fishery (GSPT) was approximately 50% of the total Indian Arm tag returns (Appendices 9 and 10). The June and July releases showed a higher percent recovery in the Georgia Strait sport fishery compared to the May releases:

Release group	% of total recovery in Georgia Strait sport fishery	
	1978 brood	1979 brood
May	38.7	36.4
June	47.2	53.6
July	45.9	51.7

A higher benefit of delayed releases to the local sport fishery was also observed for the coho from Minter Creek hatchery in Washington where the June, July, and August releases yielded an 8 to 16 times greater sports catch compared to the May release (Novotny 1980).

Percent distribution of the GSPT catch by Statistical Area for coho from Indian Arm, Capilano hatchery and Sechelt Inlet is shown in Figure 9 and Tables 7 and 8. Most of the GSPT catch of Indian Arm coho was made in Statistical Areas 14, 16, 17 and 28 (83.5% for 1978 brood year and 82.1% for 1979 brood year). However, no fishing benefits were documented for Indian Arm alone (in Area 28) since of the two brood year releases, only one tag was recovered in Indian Arm; this tag came from a 2-year old coho released in May 23, 1980 and captured in September of the same year. Most of the GSPT catch of Capilano hatchery coho was made in the same areas as reported for Indian Arm coho (84.7% for 1978 brood year and 82.2% for 1979 brood year). By comparison, Sechelt coho from the 1978 brood year were captured in the GSPT fishery primarily in Statistical Area 16 (56.8%) with smaller but significant catches made in areas 13, 14 and 17 (35.4%). All of the coho smolt releases were the Capilano stock. Therefore, the above differences in the GSPT catch distribution are related to differences in the site of rearing and release, and also the timing of release. The Sechelt site is located further north than the Capilano hatchery and Indian Arm (Fig. 8) and this is apparently related to the more northerly adult distribution of the Sechelt coho. The latter fish were also virtually absent from Area 28 which, however, showed considerable abundance of the Indian Arm and Capilano released coho.

Tag recovery data from the GSPT catch for both 1978 and 1979 Indian Arm coho brood years suggested that release timing of juveniles, perhaps in combination with size, affected adult migration routes and distribution. The percentages of GSPT recoveries made in the more northern Statistical Areas 13 - 16 were compared to the corresponding percentages for the more southern Statistical Areas 17 - 20, 28 and 29 (Table 7). The results for each release group and brood year were as follows:

Release group	Statistical Areas 13 - 16		Statistical Areas 17 - 20, 28, 29	
	1978 Brood	1979 Brood	1978 Brood	1979 Brood
May	73.8	73.3	26.2	26.8
June	69.4	66.6	30.7	33.3
July	60.4	44.0	39.6	56.0

The above data showed very similar distribution trends for the two coho broods. A significantly greater number of tags were recovered in Areas 13 to 16 compared to Areas 17 to 20, 28 and 29 for all release groups suggesting a preferred northern migratory direction. However, compared to the May releases, the later releases in June and July showed lower percentages of tags recovered in the northern areas and higher percentages recovered in the southern areas. This strongly suggests that the June and July releases had a less extensive and more southerly distribution compared to the May releases. In particular, tags recovered in Area 28 which includes Indian Arm, were proportionately twice as abundant for the July group as for the May or June groups (Table 7) indicating a more local distribution of the July releases.

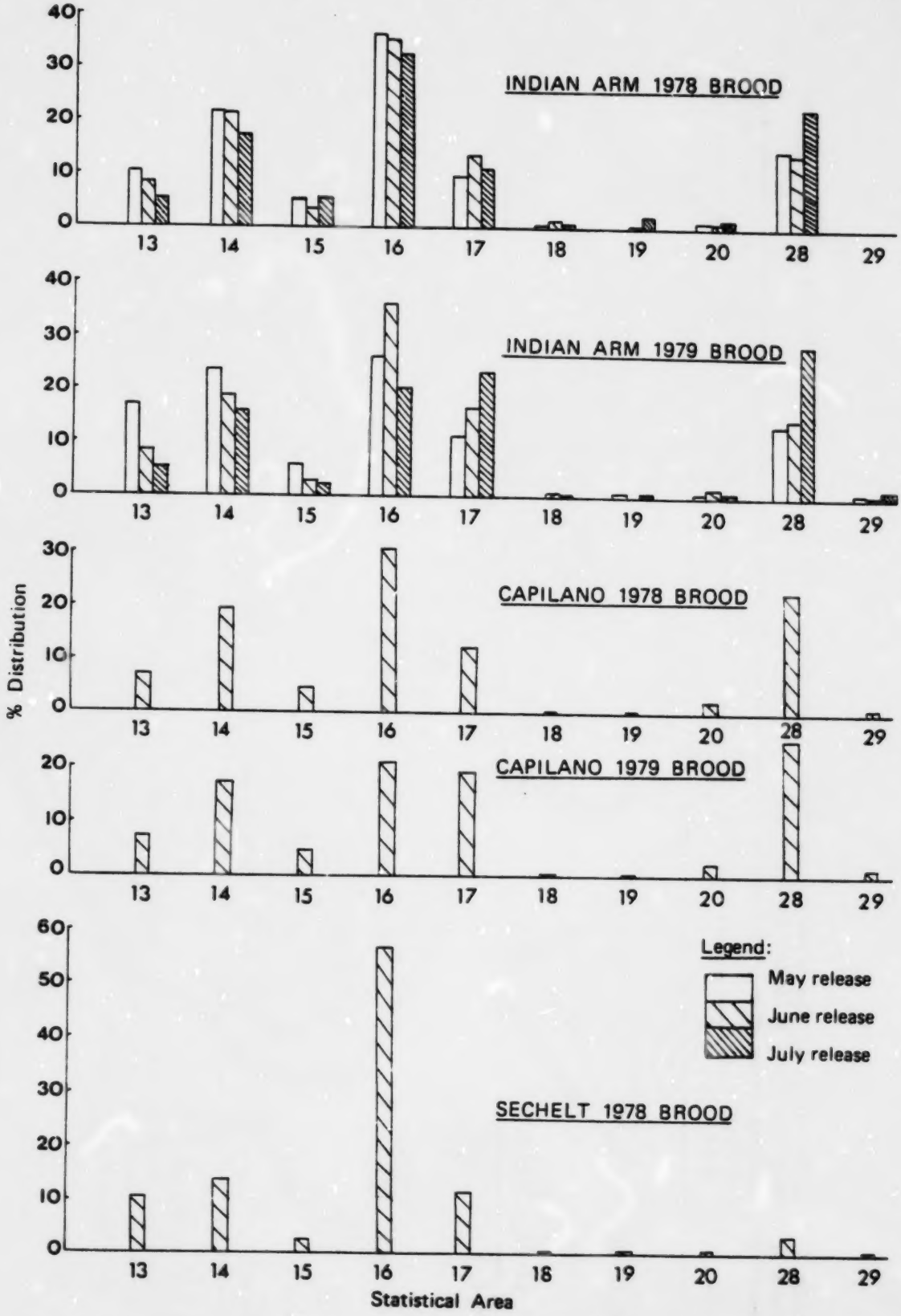

Fig. 9. Percent sports catch of coho released from Indian Arm, Capilano hatchery and Sechelt Inlet (1978 and 1979 broods) by Statistical Area, brood year and release group.

Table 7. Percent distribution of marks recovered in the Georgia Strait sport fishery (GSPT) for each release group of Indian Arm coho, 1978 and 1979 brood.[a, b]

Tag code	Release date	STATISTICAL AREA[c] 13	14	15	16	17	18	19	20	28	29	Total No. GSPT tags recovered[b]
						1978 BROOD						
02-17-13	May 23/80	10.5	21.7	5.4	36.2	9.8	0.4	0	1.1	14.9	0	276
02-17-14	June 27/80	8.8	21.4	3.9	35.3	13.6	1.5	0.2	1.2	13.9	0.2	411
02-17-12	July 28/80	5.5	17.1	5.5	32.3	11.0	1.2	2.4	1.8	22.6	0.6	164
Total	---	8.7	20.7	4.7	35.0	11.9	1.1	0.6	1.3	15.9	0.2	851
						1979 BROOD						
02-19-13	May 21/81	17.2	23.9	6.1	26.1	11.7	0	0.6	0.6	13.3	0.6	180
02-19-12	June 19/81	8.6	18.8	3.2	36.0	15.6	1.1	0	1.6	14.5	0.5	186
02-19-14	July 21/81	5.6	16.0	2.4	20.0	23.2	0.8	0.8	0.8	28.8	1.6	125
Total	---	11.0	20.0	4.1	28.3	16.1	0.6	0.4	1.0	17.7	0.8	491

[a] All ages combined.
[b] Number of tags observed, not expanded. At the time of report writing 1982 data were preliminary and 1983 data were not available; however, 1983 returns of 4-year olds (1979 brood) are probably negligible.
[c] See Figure 8 for location of Statistical Areas.

Table 8. Number and percent ( ) distribution of marks recovered in Georgia Strait sport fishery (GSPT) for Capilano hatchery coho (1978 and 1979 broods) and Sechelt coho (1978 brood).[a, b]

Tag code	Release date	Size at release (g)		STATISTICAL AREA[c] 13	14	15	16	17	18	19	20	28	29	Total No. GSPT tags recovered
							CAPILANO - 1978 BROOD							
02-17-04	June 6/80	14.1		8	24	0	43	17	1	2	2	38	1	136
02-17-05	June 6/80	14.1		15	36	11	54	23	0	2	5	64	4	214
02-17-06	June 6/80	14.1		20	61	15	89	28	0	4	4	48	1	270
02-19-24	June 6/80	12.3		32	83	21	137	63	1	0	12	93	2	444
		Total	No.	75	204	47	323	131	2	8	23	243	8	1,064
			(%)	(7.0)	(19.2)	(4.4)	(30.4)	(12.3)	(0.2)	(0.8)	(2.2)	(22.8)	(0.8)	(100)
							CAPILANO - 1979 BROOD							
02-17-54	June 6/81	15.9	No.	33	79	22	98	90	3	2	11	116	9	463
			(%)	(7.1)	(17.1)	(4.8)	(21.2)	(19.4)	(0.6)	(0.4)	(2.4)	(25.1)	(1.9)	(100)
							SECHELT - 1978 BROOD							
02-16-09	June 23 & July 16/80	21.2 & 31.5	No.	23	30	5	125	25	1	1	2	7	1	220
			(%)	(10.4)	(13.6)	(2.3)	(56.8)	(11.4)	(0.45)	(0.45)	(0.9)	(3.2)	(0.45)	(100)

[a] Only 3-year old coho tags were recovered.
[b] Data source: Bailey et al. (1983 b) and Dept. Fisheries and Oceans (MS 1984).
[c] For location of Statistical Areas see Figure 8.

SEASONAL DISTRIBUTION OF CATCH

In the B.C. commercial fishery, 85% of the catch from the 1978 brood coho and 93% of the catch from the 1979 brood coho were taken between July and August, and the rest mostly in September (Table 9). Seasonal commercial catch distribution for each release group (May, June and July) from both brood years was generally similar (Table 9).

In the Georgia Strait sport fishery, about 80% of the catch from both the 1978 and 1979 broods was taken between June and August, about 16% between January and May, and about 4% between September and December (Table 10). Seasonal sports catch distribution for each release group for both brood years was almost identical (Table 10).

COHO ADULT AGE COMPOSITION

The age composition of Indian Arm coho catch, based on tag recoveries for the 1978 brood, is given in Table 11. (4-year old tag catch from the 1979 brood is not yet available). Three-year old coho contributed 98.5% to the total 1978 brood catch; 2-year old coho contributed 1.2%; and 4-year old coho contributed 0.3%. Among the different 1978 brood release groups, coho jacks were most common in the May release group (3.0% of total catch) compared to 0.1% in the June group and 0% in the July group. The age composition for the Indian Arm June release group was generally similar to that for the Capilano hatchery and Sechelt coho of the same brood and similar release time (Table 11). Bilton (1978) found that larger smolts released on a given date and early releases of a given size produced more jacks.

The available age composition data for Indian Arm coho were representative only of the catch fraction since the escapement was not monitored. In addition, the age composition of the catch was biased due to sublegal size of jacks and the size selectivity of commercial gear against capture of jacks; consequently, majority of jacks probably returned as escapement. It is therefore expected that the age data based on catch alone underestimated the proportion of jacks. Nevertheless, the available data should provide a relative age representation for each release group if it is assumed that the gear selectivity is constant throughout the fishery.

COHO ADULT SIZE

The mean monthly and overall fork lengths of 3-year old coho recovered in the B.C. commercial fishery are shown for each brood year and release group in Figure 10 and Table 12. Size data from the considerable Georgia Strait coho sport fishery were available but not considered to be reliable. Length data for the 2-year old coho were available only for the May release group from the 1978 brood year.

The length (± 1 S.E.) of 12 coho jacks from the May release group (1978 brood) captured in the B.C. commercial fishery between August and September 1980 averaged 32.0 ± 0.4cm (range 30.5 - 35.7cm). The mean seasonal fork length for the 3-year old coho from individual release groups ranged from 48 cm for the July group (1978 brood) to 56 cm for the May group (1978 and 1979 broods; Table

Table 9. Seasonal distribution of marked coho from Indian Arm (1978 and 1979 broods) recovered in the B.C. commercial fishery from each release group (May, June, July).

Tag code	Date of release	Seasonal distribution of B.C. commercial catch[a]										Total
		June		July		August		September		October		
		No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.
1978 Brood												
02-17-13	May 23/80	4	(0.4)	320	(35.9)	408	(45.7)	160	(17.9)	0		892
02-17-14	June 29/80	1	(0.1)	284	(35.9)	400	(50.6)	105	(13.3)	0		790
02-17-12	July 28/80	2	(0.7)	102	(37.1)	151	(54.9)	20	(7.3)	0		275
Total	-	7	(0.4)	706	(36.1)	959	(49.0)	285	(14.6)	0		1957
1979 Brood												
02-19-13	May 21/81	0		348	(53.6)	239	(36.8)	58	(8.9)	4	(0.6)	649
02-19-12	June 19/81	0		152	(60.1)	92	(36.4)	9	(3.5)	0		253
02-19-14	July 21/81	0		74	(52.5)	67	(47.5)	0		0		141
Total	-			574	(55.0)	398	(38.2)	67	(6.4)	4	(0.4)	1043

[a] Data from DFO Mark Recovery Program.

Table 10. Percent of marked coho from Indian Arm (1978 and 1979 broods) recovered in the Georgia Strait sport fishery from each release group (May, June, July) and seasonal sports catch distribution.[a]

Tag code	Date of release	Estimated total marks recovered[b]	Georgia Strait sport recoveries[c]		Seasonal distribution of sports catch						
					Jan.-May		June-Aug.		Sept.-Dec		Total
			No.	(%)	No.	(%)	No.	(%)	No.	(%)	(%)
1978 Brood											
2-17-13	May 23/80	2,139	828 [d]	(38.7)	120	(14.5)	681	(82.8)	27	(3.3)	(100)
2-17-14	June 27/80	2,610	1233 [e]	(47.2)	231	(18.7)	975	(79.1)	27	(2.2)	(100)
2-17-12	July 28/80	1,072	492 [f]	(45.9)	78	(15.9)	396	(80.5)	18	(3.7)	(100)
Total	-	5,821	2553	(43.9)	429	(16.8)	2052	(80.4)	72	(2.8)	(100)
1979 Brood											
2-19-13	May 21/81	1,485 [h]	540 [g]	(36.4)	87	(16.1)	423	(78.3)	30	(5.6)	(100)
2-19-12	June 19/81	1,042 [h]	558 [g]	(53.6)	102	(18.3)	435	(78.0)	21	(3.8)	(100)
2-19-14	July 21/81	726 [h]	375	(51.6)	36	(9.6)	312	(83.2)	27	(7.2)	(100)
Total	-	3,253	1473	(45.3)	225	(15.3)	1170	(79.4)	78	(5.3)	(100)

[a] Catch for 1978 brood coho includes 2-, 3- and 4-year olds; catch for 1979 brood coho includes only 2- and 3-year olds.
[b] Includes Capilano strays.
[c] An expansion factor of 3 was applied to number of marks observed.
[d] Includes 24 2-year olds and nine 4-year-olds.
[e] Includes three 2-year-olds.
[f] Includes three 4-year-olds.
[g] Includes six 2-year-olds.
[h] Used adjusted totals (Appendix 10).

Table 11. Age composition of coho by brood year and release group for Indian Arm, Capilano hatchery and Sechelt Inlet, 1978 brood.[a]

Release date	% AGE COMPOSITION 2 year	3 year	4 year	Fish No.
		INDIAN ARM 1978 BROOD		
May 23/80	3.0	96.5	0.5	1,735
June 27/80	0.1	99.9	0	2,056
July 28/80	0	99.6	0.4	772
Total	1.2	98.5	0.3	4,563
		CAPILANO HATCHERY 1978 BROOD		
June 6/80	0.15	99.8	0.05[b]	5,313
		SECHELT INLET 1978 BROOD		
June/July/80	0.7	99.3	0	866

[a] Based on tag recoveries in B.C. catch only.
[b] 5-year-old coho.

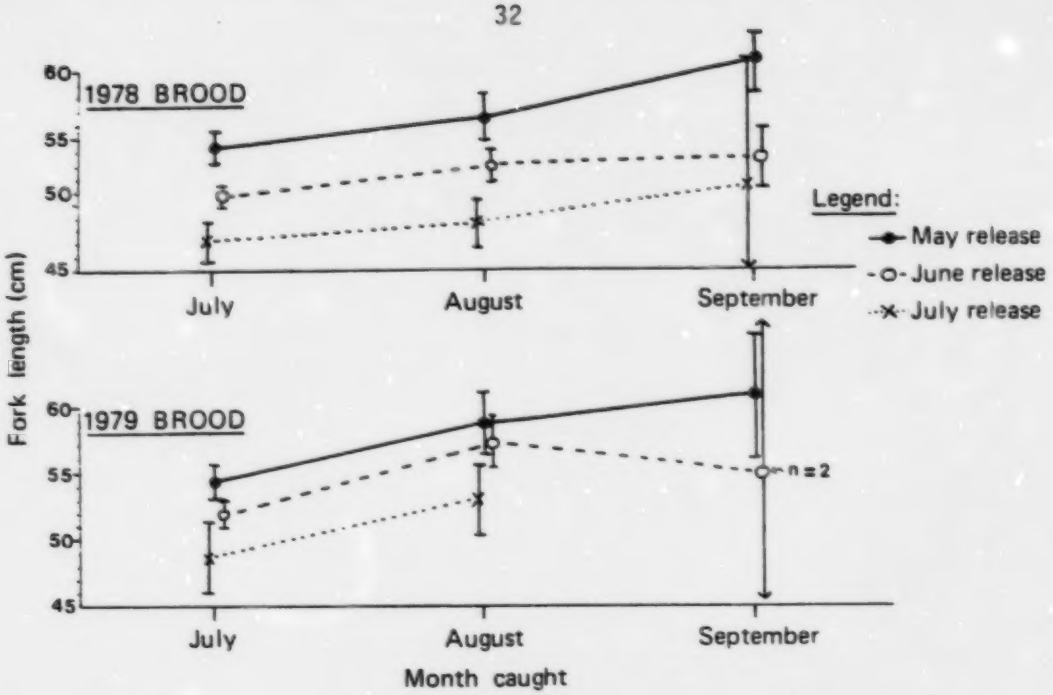

Fig. 10. Mean monthly lengths of 3-year old coho from each release group reared in Indian Arm (1978 and 1979 broods) and recovered in B.C. commercial fishery (vertical bars indicate ± 95 % C.L.).

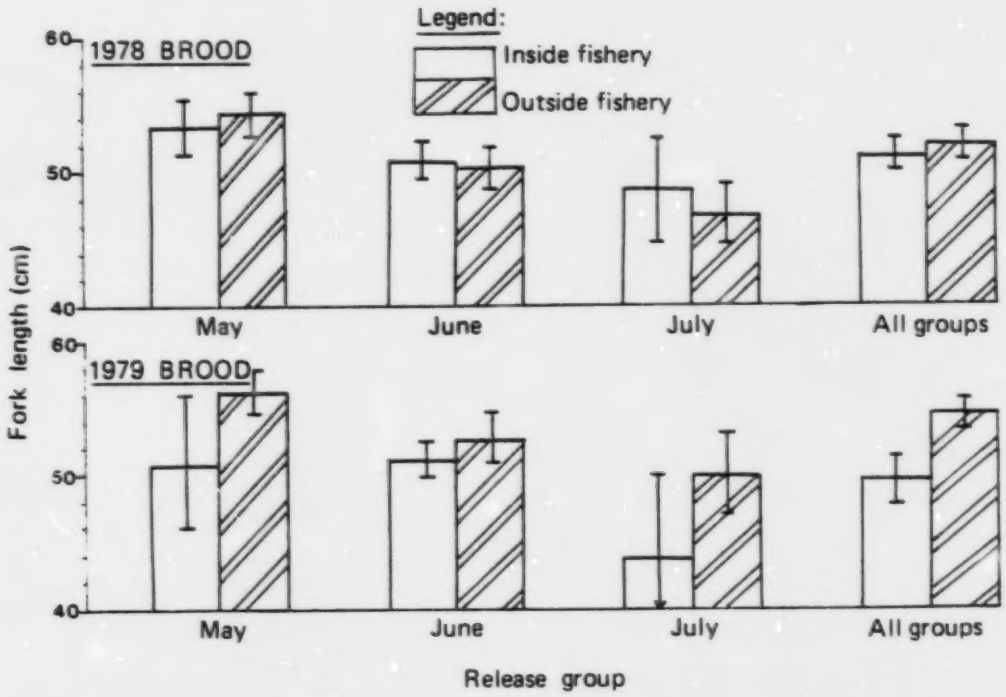

Fig. 11. Mean July lengths of 3-year old coho from each release group reared in Indian Arm (1978 and 1979 broods) and recovered in 'inside' and 'outside' B.C. commercial fisheries (vertical bars indicate ± 95% C.L.).

Table 12. Mean monthly fork length of 3-year old coho from each release group reared in Indian Arm (1978 and 1979 broods) recovered in the B.C. commercial fishery during 1981 and 1982 (n = sample size).

Tag code	Date of release	Mean wt. at release (g)	Length (cm)									
			June		July		August		September		Total	
			(n)	Mean ± 1 S.E.	(n)	Mean ± 1 S.E.	(n)	Mean ± 1 S.E.	(n)	Mean ± 1 S.E.	(n)	Mean ± 1 S.E.
1978 Brood												
02-17-13	May 23/80	~ 25	(3)	48.4 ± 1.6	(82)	54.2 ± 0.6	(71)	56.4 ± 0.9	(31)	60.5 ± 1.0	(187)	56.0 ± 0.5
02-17-14	June 27/80	29.6	(2)	51.7 ± 2.4	(83)	50.6 ± 0.4	(66)	52.8 ± 0.6	(26)	53.4 ± 1.2	(177)	51.8 ± 0.4
02-17-12	July 28/80	38.3	(1)	48.4	(22)	47.3 ± 0.8	(25)	48.5 ± 0.9	(4)	51.3 ± 2.9	(52)	48.0 ± 0.6
1979 Brood												
02-19-13	May 21/81	16	-	-[a]	(78)	54.3 ± 0.7	(37)	58.8 ± 1.1	(13)	60.6 ± 2.1	(129)[b]	56.4 ± 0.6
02-19-12	June 19/81	35	-	-	(39)	52.0 ± 0.5	(19)	57.3 ± 1.0	(2)	54.7 ± 2.9	(60)	53.8 ± 0.6
02-19-14	July 21/81	38	-	-	(18)	48.8 ± 1.3	(14)	53.0 ± 1.2	-	-	(32)	50.6 ± 1.0

[a] No data.
[b] Includes one fish captured in October.

12). At any given sampling time for both brood years, the July release group had the smallest adult size, the June group had an intermediate size and the May group the largest size. The May release group also showed the largest mean size increment between July and September (from 54 cm to 61 cm) while the June and July release groups showed a smaller size increment (Fig. 10). Size difference between the May and July groups was significant ($p < 0.05$) for all months combined and for the individual months tested (except September, 1978 brood, where the sample size was very low). The above size data suggest that coho juveniles released on progressively later dates (May vs June vs July) returned as correspondingly smaller adults. Similarly, Hopley and Mathews (MS 1975), Hager and Noble (1976), Salmon Culture Div. (1977) and Bilton (1978) also found that size of adults was affected by time of release with later releases returning at smaller size due probably to shorter ocean feeding time. In addition, for a given release time, larger smolts resulted in larger adults (Johnson 1970; Salmon Culture Div., 1977; Bilton 1978). Larger juveniles also showed a better marine survival (Johnson 1970; Hager and Noble 1976; Bilton, Alderdice and Schnute 1982). However, Bilton (1978) found that among smolts released in June, marine survival was greater from average sized compared to larger juveniles.

Mean lengths of coho captured in the "inside" B.C. waters (Georgia Strait and Fraser River) were compared for each release group and brood year to mean lengths of coho captured in the "outside" B.C. waters (Northern and Central B.C., and West Coast Vancouver Island; Fig. 11, Table 13). Statistical Areas 13 and 20 were excluded from the calculations since these areas may contain mixed populations of "inside" and "outside" rearing fish (K. Pitre, DFO, pers. comm.). Also, only the July length data were used in order to reduce size variability due to seasonal growth and to remove the "dilution factor" (during late summer and fall, the "inside" coho populations become diluted with the "outside" population returning to spawn; K. Pitre, pers. comm.).

In general, no significant size differences were observed between the "inside" and "outside" coho from the 1978 brood year. However, the 1979 brood data showed that the "outside" coho were consistently larger than the "inside" coho. This difference was observed for each release group and was significant ($p < 0.05$) for all the groups combined.

Milne (1964) observed that coho captured in the "outside" region off the west coast of Vancouver Island (Areas 21-27, Fig. 8) were consistently larger than the "inside" coho captured in Georgia Strait (Areas 13-20, 28, 29; Fig. 8). Similarly, Argue and Marshall (1976) and Argue, Marshall and Coursley (1977) noted that coho captured in Statistical Areas 13-19 showed a south to north increase in average fork length. Novotny (1980) also observed that wild coho resident inside Puget Sound have a smaller mean size at maturity than ocean-run fish.

The above observations suggest that coho adults sampled in the "inside" waters have a lower growth rate compared to coho sampled in the more open waters. Tagging studies in Georgia Strait showed that the Georgia Strait coho captured between July and September are primarily the "resident" fish that have never migrated outside the Georgia Strait (Argue and Marshall 1976). However, the Capilano stock migrates exceptionally early with peak return to freshwater

Table 13. Mean fork lengths of 3-year old coho from each release group reared in Indian Arm (1978 and 1979 broods) recovered in the B.C. commercial fishery from "inside" and "outside" regions[a] during July 1981 and 1982 (n = sample size).

Tag code	Date of release	Mean wt. at release (g)	Length (cm)					
			Inside			Outside		
			(n)	Mean ± 1 S.E.	Range	(n)	Mean ± 1 S.E.	Range
1978 Brood								
02-17-13	May 23/80	-	(14)	53.3 ± 0.9	44.7-57.1	(51)	54.3 ± 0.8	40.9-68.5
02-17-14	June 27/80	29.6	(29)	50.9 ± 0.7	43.9-57.1	(35)	50.3 ± 0.8	36.9-61.6
02-17-12	July 28/80	38.3	(7)	48.6 ± 1.6	40.8-52.4	(12)	46.9 ± 1.1	41.4-53.7
All groups		-	(49)	51.2 ± 0.6	40.8-57.1	(96)	52.0 ± 0.6	36.9-68.5
1979 Brood								
02-19-13	May 21/81	16	(6)	50.8 ± 1.9	42.8-54.6	(54)	56.1 ± 0.7	44.6-68.0
02-19-12	June 19/81	35	(14)	51.1 ± 0.6	47.6-54.3	(22)	52.6 ± 0.8	46.0-61.7
02-19-14	July 21/81	38	(5)	43.9 ± 2.2	39.9-50.9	(10)	49.8 ± 1.4	43.0-57.1
All groups		-	(25)	49.5 ± 0.9	39.9-54.6	(86)	54.5 ± 0.6	43.0-68.0

[a] "Inside" region includes Georgia Strait and Fraser River, "outside" region includes all other B.C. zones; Statistical Areas 13 and 20 were excluded.

occurring in late August or early September. The tag recovery data for the 1979 brood Indian Arm coho releases suggest that each release group had a resident Georgia Strait sub-population with smaller sized individuals and an "outside" sub-population with larger sized individuals. This size trend was not apparent for the 1978 brood coho, possibly because of limited size data and more comparable rearing conditions in the "inside" and "outside" waters for that brood year.

CONCLUSIONS

Of the three coho groups released in Indian Arm, the June group appears to provide the maximum benefit to both the local Georgia Strait sport fishery and the overall B.C. fishery. This conclusion was based on the combined effects of the relative marine survival of different release groups, as indicated by total tag recovery; their relative contribution to the Georgia Strait sport fishery; and the relative size of returning adults. By comparison, the May release group contributed least to the local sport fishery, while the July release group had the smallest adult size. It is important to note that the above results may have been influenced by site-specific factors such as fish diet and rearing environment particularly, and by annual variations in weather and ocean conditions that could affect marine survival of fish (Bilton, Alderdice and Schnute 1982). The above authors further caution that duplication of a release-return coho study at another site may show different results.

The original aim of the Indian Arm project to develop a local sport fishery on resident coho failed since no fishing benefits were documented for Indian Arm. In addition, the estimated smolt-to-adult survival of 6% to 14% obtained for coho sea-pen reared in Indian Arm, was lower than the mean survival of 15% experienced using other fish culture methods in B.C. such as full-term freshwater rearing to smolt. Freshwater rearing, for example in the Capilano hatchery, followed by release of smolts in Indian Arm may prove more successful in enhancing the Indian Arm coho sport fishery. On the other hand, sea-pen rearing bypasses the physical constraints, particularly water supply and rearing space, that limit smolt production in most hatcheries.

The present study also showed that time of release and possibly the size at release may affect fish migration routes, with later releases in June and July resulting in more limited migration.

SUMMARY

1. Approximately 120,000 coho fry from the 1978 brood year, each weighing 2-3 g, were transported from the Capilano hatchery to net pens in Indian Arm during August 1979.
   Approximately 100,000 coho fry from the 1979 brood year, each weighing 4-8 g, were transported from the Capilano hatchery to net pens in Indian Arm during September and November 1980.

2. Approximately 91,000 juveniles from the 1978 brood year were released in 1980 in three groups with mean sizes ranging from 25 g to 38 g. Overall rearing survival to release was 76%.

Approximately 85,000 juveniles from the 1979 brood year were released in 1981 in three groups with mean sizes ranging from as 16 g to 38 g. Overall rearing survival to release was 86%.

3. The 1978 brood coho were differentially tagged and released in three groups as follows:
   23,177 fish released on May 23 with code 02-17-13;
   24,961 fish released on June 27 with code 02-17-14; and
   25,432 fish released on July 28 with code 02-17-12.
   An additional estimated 18,000 coho juveniles were released from May to July unmarked or adipose-clipped only.
   The 1979 brood coho were differentially tagged and released in three groups as follows:
   25,698 fish released on May 21 with code 02-19-13;
   25,384 fish released on June 19 with code 02-19-12; and
   21,026 fish released on July 21 with code 02-19-14.
   An additional estimated 13,000 coho were released from May to July unmarked or adipose-clipped only.

4. Water temperatures during the 1979 to 1980 rearing period ranged from 6°C to 21°C. Salinities ranged from 1 to 19 parts per thousand.

   Water temperatures during the 1980 to 1981 rearing period ranged from 6°C to 16°C. Salinities ranged from 0 to 14 parts per thousand.

5. The estimated marine survival of Indian Arm coho, based on tag recovery, was 10.2% for the 1978 brood and 9.0% for the 1979 brood. Lowest marine survival was observed for the July release groups (5.5% and 6.9%) compared to the May and June release groups (8.1% - 13.5%).

6. The Georgia Strait sport fishery accounted for about 50% of the total Indian Arm tag returns from catch.

7. The June and July releases from both brood years contributed proportionately more to the "inside" fishery (Georgia Strait and Fraser River; 50% to 60%) than did the May release group (44%). Similarly, the distribution of Georgia Strait sport fishery catch indicated a less extensive migration and more southerly distribution of June and July releases compared to the May release. Therefore, release timing of coho juveniles appears to affect marine migration routes and geographical distribution of adults. Comparison of catch distribution for Capilano coho released from Indian Arm, from Capilano hatchery and from sea-pens in Sechelt Inlet indicates that release site has a major impact on marine migration routes.

8. Over 85% of the B.C. commercial catch of Indian Arm coho was taken between July and August about one year after release; about 80% of the Georgia Strait sports catch of Indian Arm coho was taken between June and August.

9. Escapement was not determined.

10. No evidence was collected of Indian Arm coho residency.

11. Age composition of the 1978 brood coho catch, based on tag recoveries, was as follows: 2-year olds - 1.2%; 3-year olds - 98.5%; 4-year olds - 0.3% (the complete 1979 brood age data are not yet available).

12. The May release group had the largest adult size and the July group the smallest. This suggests that later coho releases result in returns of smaller adults.

13. Of the three coho groups released in Indian Arm, the June group appears to provide the greatest overall benefit to the Georgia Strait sport fishery based on the combined effects of relatively better marine survival, more local distribution of adults and adult size.

14. The Indian Arm coho pen-rearing project failed to provide a year-round local sport fishery in Indian Arm but showed that release size and timing may affect coho marine survival and adult size, and did contribute to the Canadian sport and commercial fisheries 5,654 fish from the 1978 brood and 3,010 fish from the 1979 brood.

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Appendix 1. Tag returns from 1974 coho transplant from Capilano hatchery to Indian Arm (1972 brood, code 02-1-1).

Date of recovery	No. tags recovered	Capture site (Figs. 1 + 22)	Comments
1974			
week ending Aug. 31	1	Northwest troll (NW part of Van. Isl.)	Commercial fishery
1975			
Jan. 16	1	Bidwell Bay (Area 28)	Sport fishery
Jan. 23	2	Bidwell Bay (Area 28)	Sport fishery
Feb. 5	1	Bidwell Bay (Area 28)	Sport fishery
Feb. 24	1	Bidwell Bay (Area 28)	Sport fishery
June 28	2	Lasqueti Island (Area 16)	Sport fishery
July 22	1	Cowan Pt. (Area 28)	Sport fishery
Aug. 2	1	Epsom Pt. (Area 16)	Sport fishery
Total	10	-	-

Appendix 2. Mean weights of coho juveniles rearing in Indian Arm, 1979-1980.

Sampling date	Mean Weight (g)		
	Small pen[a]	Large pen No. 1[b]	Large pen No. 2[c]
1979			
June 27	1.8		
July 13	3.6		
July 24	4.9		
Aug. 7	6.5		
Aug. 20	7.5	3.0	
Sept. 5	-	5.8	5.5
Sept. 7	11.3	-	-
Sept. 22	(fry	8.5	8.1
Oct. 11	destroyed)	11.4	10.4
1980			
Mar. 3		15.0	14.2
Apr. 8		21.5[d]	-
June 27		-	29.6(released)
July 28		38.3 (released)	

[a] Contained at ponding 2,136 fry.
[b] Contained at ponding 50,000 fry.
[c] Contained at ponding 70,000 fry.
[d] Mean of two samples (18 g and 25 g).

Appendix 3. Mean weights (Wt) and accumulated thermal units (ATU) for coho juveniles rearing in Indian Arm, 1980-1981.

Sampling Date	Pen No. 1		Pen No. 2		Pen No. 3	
	Wt. (g)	ATU	Wt. (g)	ATU	Wt. (g)	ATU
1980						
Sept. 6	5.3[a]	2261				
Sept. 9	-	-	3.5[a]	2041		
Sept. 24	-	-	5.0[a]	-		
Oct. 16	-	-	-	-	4.1[a]	2409
Nov. 6	10.0	3128	7.5	2812	4.25	2671
Nov. 13	-	-	8.0[a]	-	-	-
Dec. 10	11.0	3409	6.3	3093	4.6	2952
1981						
Jan. 5	11.0	3576	7.6	3260	3.5	3119
Feb. 2	12.8	3773	9.4	3457	6.7	3316
Mar. 5	16.4	4003	12.0	3687	7.0	3546
Apr. 1	18.1	4221	13.7	3905	7.5	3764
May 11	20.4	4558	20.0	4242	15.4	4101
May 21	-	-	16.0	4362	-	-
June 12	34.0	4825	-	-	21.0	4489
June 19	35.0	4918	-	-	-	-
July 7	-	-	-	-	31.2	4591
July 21	-	-	-	-	38.0	4802

[a] Weight at ponding

Appendix 4. Mean lengths (L) of coho juveniles rearing in Indian Arm, 1980-1981 (n = 100 fish/sample).

Sampling date	Pen No. 1		Pen No. 2		Pen No. 3	
	L ± 1 S.E. (cm)	(Range)	L ± 1 S.E. (cm)	(Range)	L ± 1 S.E. (cm)	(Range)
1980						
Sept. 22	7.5 ± 0.1	(5.0-10.0)	6.6 ± 0.1	(4.1-8.5)	--	
Mar. 10	10.4 ± 0.1	(7.3-14.4)	--		--	
Mar. 13	--		9.1 ± 0.1	(6.6-11.9)	--	
Mar. 17	--		--		8.9 ± 0.1	(6.4-11.5)
May 21	--		11.2 ± 0.1	(7.8-13.8)	--	
June 19	14.6 ± 0.2	(10.2-19.4)	--		--	
July 21	--		--		13.9 ± 0.2	(8.4-18.1)

Appendix 5. Mean weekly surface water temperatures at the Indian Arm coho rearing site, 1979 - 1980.

Week ending	Temperature (°C)	Week ending	Temperature (°C)
1979		1980	
July 1	15.5	Jan. 6	7.5
July 8	16.0	Jan. 13	6.5
July 15	17.0	Jan. 20	6.5
July 22	19.0	Jan. 27	6.5
July 29	20.0	Feb. 3	7.0
Aug. 5	21.0	Feb. 10	5.5
Aug. 12	21.0	Feb. 17	5.5
Aug. 19	19.0	Feb. 24	6.0
Aug. 26	18.0	Mar. 2	6.0
Sept. 2	18.0	Mar. 9	6.5
Sept. 9	14.0	Mar. 16	6.5
Sept 16	13.0	Mar. 23	7.0
Sept 23	15.0	Mar. 30	7.5
Oct. 7	15.0	Apr. 6	7.5
Oct. 14	13.0	Apr. 13	8.0
Oct. 21	12.0	Apr. 20	8.0
Oct. 28	10.5	Apr. 27	9.0
Nov. 4	11.0	May 4	10.0
Nov. 11	10.5	May 11	11.0
Nov. 18	10.5	May 18	11.0
Nov. 25	10.0	May 25	11.0
Dec. 2	8.0	June 1	12.0
Dec. 9	8.0	June 8	12.0
Dec. 16	7.0	June 15	13.0
Dec. 23	7.0	June 22	15.0
Dec. 30	7.0	June 29	15.0
		July 6	15.0
		July 13	16.0
		July 20	16.0
		July 28	20.0

Appendix 6. Mean weekly water temperatures at 0.6 m depth at the Indian Arm coho rearing site, 1980 - 1981.

Week ending	Temperature (°C)	Week ending	Temperature (°C)
1980		1981	
Sept. 6	16.0	Jan 3	6.5
Sept. 13	15.0	Jan 10	7.0
Sept. 20	14.0	Jan 17	7.0
Sept. 27	14.0	Jan 23	7.5
Oct. 4	13.0	Jan 30	7.5
Oct. 11	13.0	Feb. 6	7.0
Oct. 18	12.5	Feb. 13	8.0
Oct. 25	11.0	Feb. 20	6.5
Nov. 1	10.0	Feb. 27	7.0
Nov. 8	9.0	Mar. 6	7.5
Nov. 15	8.0	Mar. 13	8.0
Nov. 22	8.0	Mar. 20	9.0
Nov. 29	8.0	Mar. 27	10.0
Dec. 6	7.0	Apr. 3	8.0
Dec. 13	6.0	Apr. 10	8.0
Dec. 20	6.0	Apr. 17	7.5
Dec. 27	7.0	Apr. 24	8.0
		May 1	8.5
		May 8	8.0
		May 15	11.0
		May 22	12.0
		May 29	12.5
		June 5	12.0
		June 12	12.0
		June 19	12.0
		June 26	10.5
		July 3	13.5
		July 10	14.0

Appendix 7. Salinity at the surface and 1m depths at the Indian Arm coho rearing site, July - December 1979.

Date	Salinity (°/oo)		Date	Salinity (°/oo)	
	Surface	1m		Surface	1m
July 1	12.0	16.5	Oct. 7	11.5	13.5
July 8	15.5	16 0	Oct. 14	14.0	16.5
July 15	6.5	12.0	Oct. 21	9.0	17.0
July 22	14.0	16.5	Oct. 28	1.5	16.0
July 29	14.0	15.0	Nov. 4	11.0	15.0
Aug. 5	9.5	15.5	Nov. 11	10.5	13.5
Aug. 12	7.0	10.0	Nov. 18	5.0	8.0
Aug. 19	14.0	19.0	Nov. 25	2.0	11.5
Aug. 26	12.0	16.0	Dec. 2	14.0	14.0
Sept. 2	2.0	16.0	Dec. 9	2.0	9.0
Sept. 9	2.0	10.0	Dec. 16	1.0	6.0
Sept. 16	9.5	16.0	Dec. 23	8.0	11.0
Sept. 23	10.0	14.5	Dec. 30[a]	4.0	9.0
Sept. 30	5.5	14.5			

[a] Measurements discontinued after December 30 due to equipment failure.

Appendix 8. Salinity at 1.8m depth at the Indian Arm coho rearing site, 1980-1981.

Date	Salinity (°/oo)	Date	Salinity (°/oo)	Date	Salinity (°/oo)
1980		1981		1981 (cont'd)	
Sept. 6	7.0	Jan. 3	0	May 1	10.0
Sept. 13	8.0	Jan. 10	9.0	May 8	8.5
Sept. 20	13.0	Jan. 17	7.0	May 15	7.0
Sept. 27	13.5	Jan. 23	12.0	May 22	7.0
Oct. 4	13.5	Jan. 30	10.0	May 29	9.0
Oct. 11	13.5	Feb. 6	11.0	June 5	9.0
Oct. 18	13.0	Feb. 13	12.0	June 12	8.0
Oct. 25	13.0	Feb. 20	0	June 19	7.0
Nov. 1	13.5	Feb. 27	4.5	June 26	7.5
Nov. 8	13.0	Mar. 6	8.0	July 3	9.0
Nov. 15	7.5	Mar. 13	9.0	July 10	8.0
Nov. 22	0	Mar. 20	10.0	July 17	8.0
Nov. 29	9.5	Mar. 22	11.0	July 24	9.0
Dec. 6	8.5	Apr. 3	10.0		
Dec. 13	13.0	Apr. 10	9.0		
Dec. 20	6.0	Apr. 17	10.0		
Dec. 27	0	Apr. 24	5.0		

Appendix 9a. Mark recoveries and catch distribution of 2-, 3- and 4-year old coho pen-reared in Indian Arm, May release group, 1978 brood.[a, b]

Tag code	Release date	Mean release wt. (g)	No. tags released[d]	Catch year	Canadian catch[c]			U.S. catch			Total catch[c]	Escapement
					Troll	Net	Sport	Alaska	Wash.	Oreg.		
02-17-13	May 23/80	~ 25	23,177	1980	0	28	24	0	0	0	52	N/A[d]
				1981	380	485	798	4	345	55	2,067	N/A
				1982	0	0	9	0	0	0	9	N/A
				Total	380	513	831	4	345	55	2,128	645[e]

Catch year	B.C. TAG DISTRIBUTION[f]													
	Georgia Strait			Juan de Fuca Strait Net	Johnstone Strait Net	West Coast V.I.			North + Central B.C.			Fraser River Gillnet	Capilano strays	Total
	Troll	Net	Sport			Troll	Net	Sport	Troll	Net	Sport			
1980	0	8	24	0	9	0	0	0	0	7	0	4	0	52
1981	43	19	795	155 9	270	285 9	1	3	52	8	0	32	11	1,674[h]
1982	0	0	9	0	0	0	0	0	0	0	0	0	0	9
Total	43	27	828	155	279	285	1	3	52	15	0	36	11	1,735

[a] Data sources: B.C. recovery data from Bailey et al. (1983 a + b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recoveries for 4-year olds were preliminary and U.S. tag recoveries were not available; here, U.S. tag returns for 4-year olds are assumed to be zero.

[c] Excludes strays to Capilano hatchery.

[d] Not available.

[e] Used C/E ratio for 1978 brood Capilano coho of 3.3/1 (Table 5).

[f] See Figure 8 and Appendix 13 for location of these areas.

[g] Includes two non-randomly recovered tags with no expansion factor.

[h] Includes one tag recovered from an unknown B.C. fishing zone.

Appendix 9b. Mark recoveries and catch distribution of 2-, 3- and 4-year old coho pen-reared in Indian Arm, June release group, 1978 brood. [a, b]

Tag code	Release date	Mean release wt. (g)	No. tags released	Catch year	Canadian catch [c]			U.S. catch [c]			Total catch [c]	Escapement
					Troll	Net	Sport	Alaska	Wash.	Oreg.		
02-17-14	June 27/80	29.6	24,961	1980	0	0	3	0	0	0	3	N/A [d]
				1981	329	461	1,239	0	520	34	2,583	N/A
				1982	0	0	0	0	0	0	0	N/A
				Total	329	461	1,242	0	520	34	2,586	784 [e]

Catch year	B.C. TAG DISTRIBUTION [f]																
	Georgia Strait			Juan de Fuca Strait Net	Johnstone Strait Net	West Coast V.I.			North + Central B.C.			Fraser River Gillnet	Capilano strays	Total
	Troll	Net	Sport			Troll	Net	Sport	Troll	Net	Sport			
1980	0	0	3	0	0	0	0	0	0	0	0	0	0	3
1981	67 [g]	39 [h]	1,230	231 [h]	156 [h]	236 [i]	22	3	26	0	6	13 [h]	24	2,053 [j]
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	67	39	1,233	231	156	236	22	3	26	0	6	13	24	2,056

[a] Data sources: B.C. recovery data from Bailey et al. (1983 a + b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recoveries for 4-year olds were preliminary and U.S. tag recoveries were not available; here, U.S. tag returns for 4-year olds are assumed to be zero.

[c] Excludes strays to Capilano hatchery.

[d] Not available.

[e] Used C/E ratio for 1978 brood Capilano coho of 3.3/1 (Table 5).

[f] See Figure 8 and Appendix 13 for location of these areas.

[g] Includes two non-randomly recovered tags with no expansion factor.

[h] Includes one non-randomly recovered tag with no expansion factor.

[i] Includes five non-randomly recovered tags with no expansion factor.

[j] Includes one tag recovered from an unknown B.C. fishing zone.

Appendix 9c. Mark recoveries and catch distribution of 2-, 3- and 4-year old coho pen-reared in Indian Arm, July release group, 1978 brood.[a, b]

Tag code	Release date	Mean release wt. (g)	No. tags released	Catch year	Canadian catch[c]			U.S. catch			Total catch[c]	Escapement
					Troll	Net	Sport	Alaska	Wash.	Oreg.		
02-17-12	July 28/80	38.3g	25,432	1980	0	0	0	0	0	0	0	N/A[d]
				1981	137	138	489	0	292	8	1,064	N/A
				1982	0	0	3	0	0	0	3	N/A
				Total	137	138	492	0	292	8	1,067	323[e]

Catch year	B.C. TAG DISTRIBUTION[f]													
	Georgia Strait			Juan de Fuca Strait Net	Johnstone Strait Net	West Coast V.I.			North + Central B.C.			Fraser River Gillnet	Capilano strays	Total
	Troll	Net	Sport			Troll	Net	Sport	Troll	Net	Sport			
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	409	1	489	106[g]	28	89	0	0	8	0	0	3	5	769
1982	0	0	3	0	0	0	0	0	0	0	0	0	0	3
Total	40	1	492	106	28	89	0	0	8	0	0	3	5	772

[a] Data sources: B.C. recovery data from Bailey et al. (1983 a + b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recoveries for 4-year olds were preliminary and U.S. tag recoveries were not available; here, U.S. tag returns for 4-year olds are assumed to be zero.

[c] Excludes strays to Capilano hatchery.

[d] Not available.

[e] Used C/E ratio for 1978 brood Capilano coho of 3.3/1 (Table 5).

[f] See Figure 8 and Appendix 13 for location of these areas.

[g] Includes two non-randomly recovered tags with no expansion factor.

Appendix 10a. Mark recoveries and catch distribution of 2-, 3- and 4-year old coho pen-reared in Indian Arm, May release group, 1979 brood.[a, b]

Tag code	Release date	Mean release wt. (g)	No. tags released	Catch year	Canadian catch[c] Troll	Net	Sport	U.S. catch Alaska	Wash.	Oreg.	Total catch	Escapement
02-19-13	May 21/81	16.0	25,698	1981	0	0	6	0	4	0	10	N/A[d]
				1982	342	307	543	0	57[e]	0	1,249+	N/A
				1983	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
				Total	342	307	549	(<—— 281 ——>)[f]			1,479[c]	1,479[g]

Catch year	B.C. TAG DISTRIBUTION[h] Georgia Strait Troll	Net	Sport	Juan de Fuca Strait Net	Johnstone Strait Net	West Coast V.I. Troll	Net	Sport	North + Central B.C. Troll	Net	Sport	Fraser River Gillnet	Capilano strays	Total
1981	0	0	6	0	0	0	0	0	0	0	0	0	0	6
1982	74	8	534[i]	47	237	178	4[j]	0	90	2	9	9	6	1,198
1983	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0[k]	N/A
Total	74	8	540	47	237	178	4	0	90	2	9	9	6	1,204

[a] Data sources: B.C. recovery data from Bailey et al. (1983 b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recovery data for 3-year olds were preliminary and U.S. tag recoveries were observed, not estimated. Also, 1983 tag recoveries for 4-year olds were not available for B.C. or U.S. and are here assumed to be zero.

[c] Excludes strays to Capilano hatchery.

[d] Not available.

[e] Observed, not estimated.

[f] Adjusted U.S. catch estimate utilizing U.S. catch proportion of total catch for 1978 brood, May release group, of 19.0%.

[g] Used C/E ratio for 1979 brood Capilano coho of 1/1 (Table 5).

[h] See Figure 8 and Appendix 13 for location of these areas.

[i] Includes two tags from a combination area (Johnstone Strait and Georgia Strait).

[j] Includes one non-randomly recovered tag with no expansion factor.

[k] Elden Stone, Capilano hatchery (pers. comm.).

Appendix 10b. Mark recoveries and catch distribution of 2-, 3- and 4-year old coho pen-reared in Indian Arm, June release group, 1979 brood.[a, b]

Tag code	Release date	Mean release wt. (g)	No. tags released	Catch year	Canadian catch[c] Troll	Net	Sport	U.S. catch Alaska	Wash.	Oreg.	Total catch	Escapement
02-19-12	June 19/81	35.0	26,384	1981	0	0	6	0	4	0	6	N/A[d]
				1982	142	112	552	0	57[e]	0	863+	N/A
				1983	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
				Total	142	112	568	(← 221 →)[f]			1,033[c]	1,033[g]

Catch year	B.C. TAG DISTRIBUTION[h] Georgia Strait Troll	Net	Sport	Juan de Fuca Strait Net	Johnstone Strait Net	West Coast V.I. Troll	Net	Sport	North + Central B.C. Troll	Net	Sport	Fraser River Gillnet	Capilano strays	Total
1981	0	0	6	0	0	0	0	0	0	0	0	0	0	6
1982	47	1[i]	552	60	37	86[j]	7	0	9	0	0	7	9	815
1983	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0[k]	N/A
Total	47	1	558	60	37	86	7	0	9	0	0	7	9	821

[a] Data sources: B.C. recovery data from Bailey et al. (1983 b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recovery for 3-year olds were preliminary and U.S. tag recoveries were observed, not estimated. Also, 1983 tag recoveries for 4-year olds were not available for B.C. or U.S. and are here assumed to be zero.

[c] Excludes strays to Capilano hatchery.

[d] Not available.

[e] Observed, not estimated.

[f] Adjusted U.S. catch estimate utilizing U.S. catch proportion of total catch for 1978 brood, June release group, of 21.4%.

[g] Used C/E ratio for 1979 brood Capilano coho of 1/1 (Table 5).

[h] See Figure 8 and Appendix 13 for location of these areas.

[i] Includes one tag from a combination area (Johnstone Strait and Georgia Strait).

[j] Includes one non-randomly recovered tag with no expansion factor.

Appendix 10c. Mark recoveries and catch distribution of 2-, 3- and 4-year old coho pen-reared in Indian Arm, July release group, 1979 brood.[a, b]

Tag code	Release date	Mean release wt. (g)	No. tags released	Catch year	Canadian catch[c]			U.S. catch			Total catch	Escapement
					Troll	Net	Sport	Alaska	Wash.	Oreg.		
02-19-14	July 21/81	38.0	21,026	1981	0	0	0	0	4	0	10	N/A[d]
				1982	86	55	378	0	67[e]	0	586+	N/A
				1983	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
				Total	86	55	378	(<—— 203 ——>)[f]			722[c]	722[g]

Catch year	B.C. TAG DISTRIBUTION[h]													
	Georgia Strait			Juan de Fuca Strait Net	Johnstone Strait Net	West Coast V.I.			North + Central B.C.			Fraser River Gillnet	Capilano strays	Total
	Troll	Net	Sport			Troll	Net	Sport	Troll	Net	Sport			
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	22	0	375	43	6	64	0	0	0	0	3	6	4	523
1983	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0[i]	N/A
Total	22	0	375	43	6	64	0	0	0	0	3	6	4	523

[a] Data sources: B.C. recovery data from Bailey et al. (1983 b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recovery for 3-year olds were preliminary and U.S. tag recoveries were observed, not estimated. Also, 1983 tag recoveries for 4-year olds were not available for B.C. or U.S. and are here assumed to be zero.

[c] Excludes strays to Capilano hatchery.

[d] Not available.

[e] Observed, not estimated.

[f] Adjusted U.S. catch estimate utilizing U.S. catch proportion of total catch for 1978 brood, July release group, of 28.1%.

[g] Used C/E ratio for 1979 brood Capilano coho of 1/1 (Table 5).

[h] See Figure 8 and Appendix 13 for location of these areas.

[i] Eldon Stone, Capilano hatchery (pers. comm.).

Appendix 11. Mark recoveries by tag code and catch distribution of 2-, 3- and 4-year old coho reared in Capilano hatchery, 1978 and 1979 broods.[a, b]

Tag code	Release date	No. tags released	Mean release wt. (g)	Catch year	Canadian catch			U.S. catch			Total catch	Escapement (hatchery)[c]	B.C. TAG DISTRIBUTION[d]								
													Georgia Strait			Juan de Fuca St.		Fraser R.	Other			
					Troll	Net	Sport	Alaska	Wash.	Oreg.			Troll	Net	Sport[e]	Troll	Net	Gillnet	Troll	Net	Sport	Total
												1978 BROOD										
02-17-01	June 6/80	9,568	14.1	1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				1981	98	101	411	0	168	1	779	201	30	1	408	0	88	6	68	6	3	610
				1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Total	98	101	411	0	168	1	779	201	30	1	408	0	88	6	68	6	3	610
02-17-05	June 6/80	9,819	14.1	1980	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	3	3
				1981	145	188	642	0	263	10	1,248	352	44	66	642	0	74	13	101	35	0	975
				1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Total	145	188	645	0	263	10	1,251	352	44	66	642	0	74	13	101	35	3	978
02-17-06	June 6/80	10,117	14.1	1980	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0
				1981	150	291	810	0	302	19	1,572	406	48	66	810	0	134	39	102	53	0	1,251
				1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				1983	0	0	3	0	0	0	3	0	0	0	?	0	0	0	0	0	3	3
				Total	150	291	813	0	302	19	1,575	430	48	66	810	0	134	39	102	53	3	1,254
02-19-24	June 6/80	24,448	12.3	1980	0	2	3	0	0	0	5	14	0	0	0	0	0	0	0	2	3	5
				1981	609	519	1,338	0	129	190	2,786	938	121	51	1,332	0	310	16	488	142	6	2,466
				1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Total	609	521	1,341	0	129	190	2,791	952	121	51	1,332	0	310	16	488	144	9	2,471
Total	June 6/80	53,942	13.3[f]	1980	0	2	6	0	0	0	8	38	0	0	0	0	0	0	0	2	6	8
				1981	1,012	1,099	3,201	0	862	220	6,384	1,897	243	183	3,192	0	606	74	759	236	9	5,302
				1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				1983	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	3	3
				Total	1,012	1,101	3,210	0	862	220	6,395	1,935	243	183	3,192	0	606	74	759	238	18	5,313

Appendix 11. (cont'd)

Tag code	Release date	No. tags released	Mean release wt. (g)	Catch year	Canadian catch			U.S. catch			Total catch	Escapement [c] (hatchery)	B.C. TAG DISTRIBUTION [d]									
					Troll	Net	Sport	Alaska	Wash.	Oreg.			Georgia Strait			Juan de Fuca St.		Fraser R.	Other			
													Troll	Net	Sport[e]	Troll	Net	Gillnet	Troll	Net	Sport	Total
												1979 BROOD										
02-17-54	June 6/81	52,709	15.9	1981	0	0	3	0	0	0	3	78	0	0	3	0	0	0	0	0	0	3
				1982	570 [g]	284 [g]	1,392 [g]	0	252 [h]	N/A [i]	N/A	2,649	169	0	1,389	0	154	36	401	94	3	2,246
				1983	5 [g]	0	12 [g]	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
				Total	575	284	1,407	0	368 [j]	93 [j]	2,727 [k]	2,727	169	0	1,392	0	154	36	401	94	3	2,249

[a] Data sources: B.C. recovery data from Bailey et al. (1983 a + b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recovery data were preliminary and U.S. tag recoveries were observed, not estimated. Also 1983 B.C. tag recoveries were observed, not estimated. Also, 1983 tag recoveries for 4-year olds were generally not available for B.C. or U.S.

[c] Hatchery escapement estimates may be revised slightly; estimates are conservative since food fish catch in the river was not sampled.

[d] See Figure 8 and Appendix 13 for location of these areas.

[e] Observed B.C. sports catch expanded by a factor of 3.

[f] Weighted mean.

[g] Preliminary estimates.

[h] Observed recoveries.

[i] Not available.

[j] Adjusted estimate utilizing U.S. catch proportion for 1978 brood of 13.5% for Washington and 3.4% for Oregon catch.

[k] Estimated value.

Appendix 12. Mark recoveries and catch distribution of 2-, 3- and 4-year old coho pen-reared in Sechelt Inlet, 1978 brood.[a, b]

Tag code	Release date	Mean release wt. (g)	No. tags released	Catch year	Canadian catch			U.S. catch	Total catch	Escapement
					Troll	Net	Sport	Wash. & Oreg.		
02-16-09	June 23/80	21.2	19,966	1980	0	0	6	0	6	N/A [c]
	July 16/80	31.5		1981	137	63	660	122	982	N/A
				1982	0	0	0	0	0	N/A
				Total	137	63	666	122	988	299 [d]

Catch year	B.C. TAG DISTRIBUTION [e]									
	Georgia Strait			Juan de Fuca Strait Net	Johnstone Strait Net	West Coast V.I.		North + Central B.C. Troll	B.C. Combination Region	Total
	Troll	Net	Sport [f]			Troll	Net			
1980	0	0	6	0	0	0	0	0	0	6
1981	16	0	660	38	18	101	7	19	1	860
1982 [g]	0	0	0	0	0	0	0	0	0	0
Total	16	0	666	38	18	101	7	19	1	866

[a] Data sources: B.C. recovery data from Bailey et al. (1983 a + b) and Dept. Fisheries and Oceans (MS 1984); U.S. recovery data from Washington Dept. Fisheries Coded Wire Tag Data Base.

[b] At the time of report writing, 1982 B.C. tag recoveries for 4-year olds were preliminary and U.S. tag recoveries were not available; here, U.S. tag returns for 4-year olds are assumed to be zero.

[c] Not available.

[d] Used C/E ratio for 1978 brood Capilano coho of 3.3/1 (Table 5).

[e] See Figure 8 and Appendix 13 for location of these areas.

[f] Observed B.C. sports catch expanded by a factor of 3.

[g] Preliminary estimates.

Appendix 13. Catch regions and their corresponding Statistical Areas in British Columbia.

Catch region[a]	Abbreviation	Corresponding Statistical Areas
Northern Troll	NTR	1-5
Central Troll	CTR	6-12, 30
Northern Vancouver Island Troll	NWTR	25, 26, 27
Southwest Vancouver Island Troll	SWTR	21, 23, 24
Juan de Fuca Troll	JFTR	20
Georgia Strait Troll	GSTR	13-18, 29A
Combination Region	NTR/CTR	1-5, 6-12, 30
Combination Region	C/NWTR	25-27, 6-12, 30
Combination Region	NW/SWTR	21, 23, 24-27
Northern Net	NN	1-5
Central Net	CN	6-11
Northwest Vancouver Island Net	NWVN	25-27
Southwest Vancouver Island Net	SWVN	21-24
Juan de Fuca Net	JFN	20
Johnstone Strait Net	JSN	12, 13
Georgia Strait Net	GSN	14-18
Fraser River Gillnet	FGN	29A-29E
Combination Region	NN/CN	1-5, 6-11
Combination Region	GSN/FGN	14-18, 29A-29E
Northern Sport	NSPT	1-5
Central Sport	CSPT	6-12, 30
West Coast Vancouver Island Sport	WSPT	21-27
Georgia Strait Sport	GSPT	13-20, 28, 29